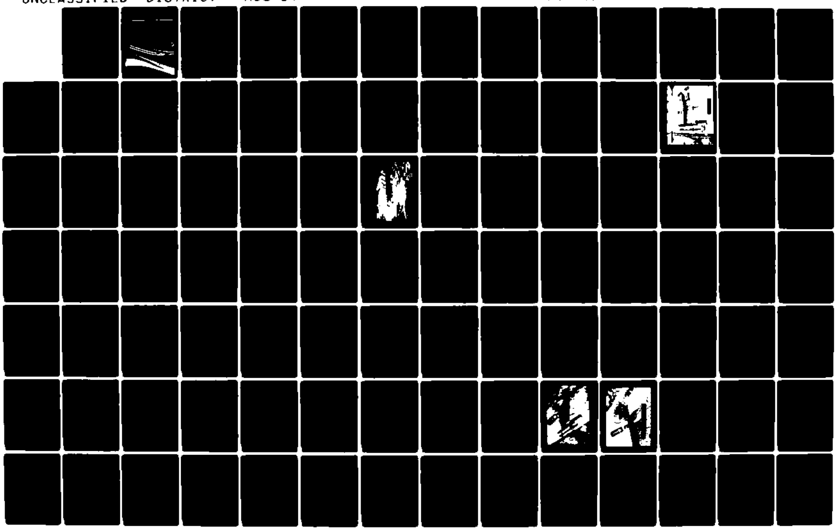
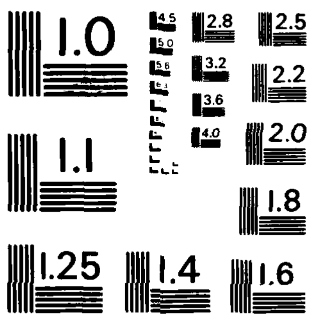
AD-A145 898 LOCKS AND DAM 1 (FORD DAM) MISSISSIPPI RIVER DRAFT 1/3
FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT FOR
HYDROPOWER(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL
UNCLASSIFIED DISTRICT AUG 84 F/G 13/2 NL

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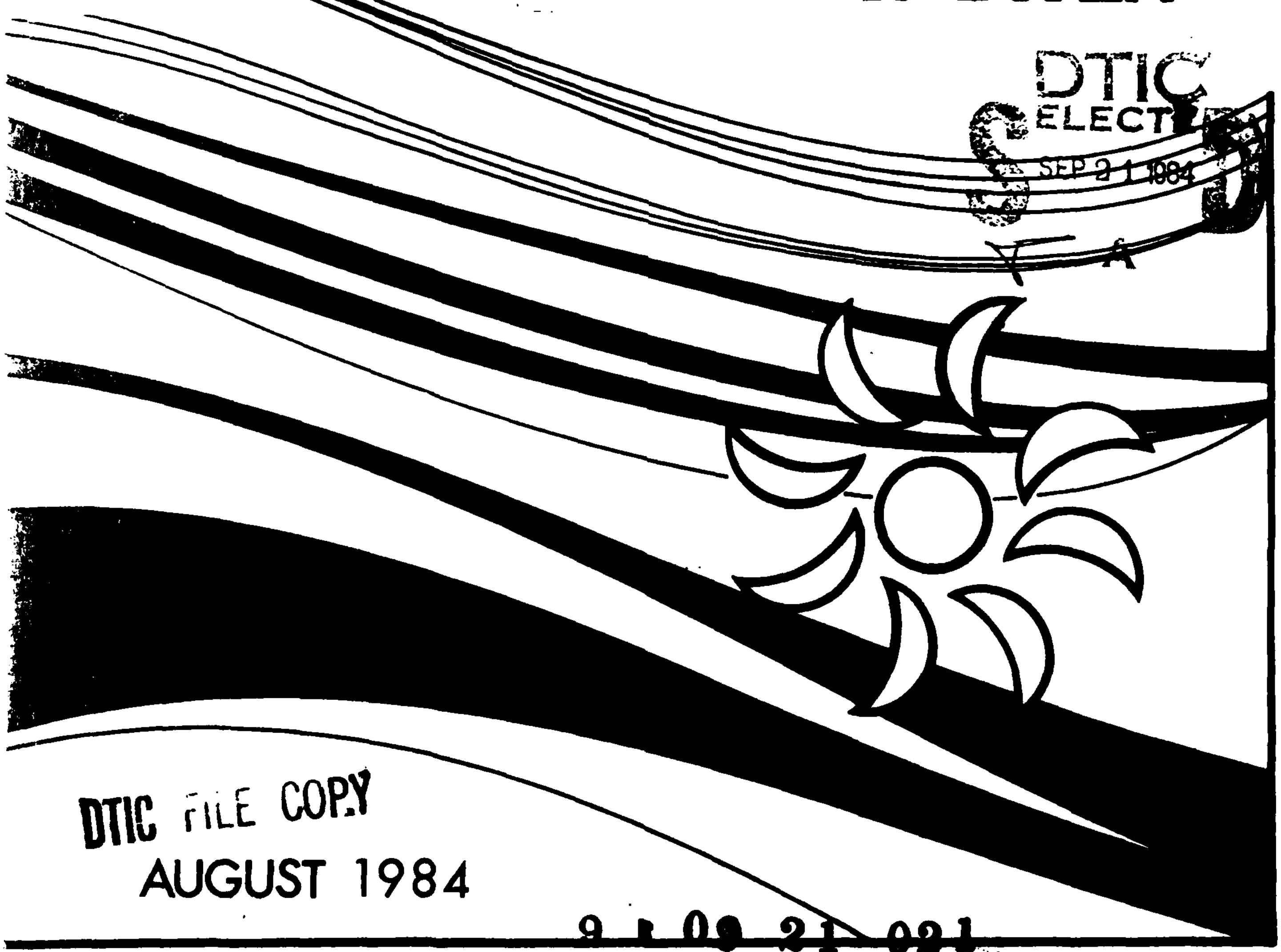
US Army Corps of Engineers
St. Paul District

AD-A145 898

Locks and Dam 1 (Ford Dam)
Mississippi River

DRAFT FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT

HYDROPOWER



AUGUST 1984

2

FEASIBILITY REPORT

FOR HYDROPOWER

LOCKS AND DAM 1

MISSISSIPPI RIVER

ST. PAUL/MINNEAPOLIS, MINNESOTA

FEASIBILITY REPORT FOR HYDROPOWER
LOCKS AND DAM 1
MISSISSIPPI RIVER
ST. PAUL/MINNEAPOLIS, MINNESOTA

SYLLABUS

This report presents a detailed evaluation of additional hydropower potential at locks and dam 1. An earlier evaluation in a reconnaissance level report (September 1981) indicated preliminary feasibility for added hydropower at this Federal navigation project site. The original Federal navigation locks and dam project included a foundation for a hydropower plant to be developed by non-Federal interests. The existing hydropower plant and equipment are owned and operated by the Ford Motor Company. The existing four turbines generate a combined nameplate capacity of 14.4 MW (megawatts).

This study was conducted under the assumption that the Federal Government would develop additional hydropower at locks and dam 1. This study concludes that an additional hydroelectric capacity of 7.2 MW would be the optimum amount that could be added to this site. That capacity would produce additional average annual energy of 21,450 MWh (megawatt-hours). The added energy tentatively recommended by this draft report would equate to burning 36,500 barrels of oil or 10,000 tons of coal per year.

The total investment first cost of the tentatively recommended hydropower development would be $11,607,000 or $1,035,000 on an average annual basis, including $92,000 for operation, maintenance, and replacements. Average annual benefits based on the avoided costs of a fossil fuel plant are $1,151,000. The net annual benefits (annual benefits minus annual costs) are $116,000. The benefit-cost ratio is 1.11 based on an 8-1/8-percent discount rate, 100-year project life, and October 1983 price levels.

Hydropower is one of the more ecologically-sound means of producing electricity because it uses a nonpolluting renewable energy source, falling water, thereby helping to conserve nonrenewable energy sources. Significant detrimental environmental impacts are not expected to result from construction and operation of the proposed project. Many of the impacts normally associated with hydropower development would not occur because no new impoundment or changed plan of regulating river flows would be required. More detailed information is in the environmental assessment section of this main report.

The St. Paul District Engineer recommends development of added hydroelectric power generation at the Mississippi River locks and dam 1 site. The District Engineer further recommends authorization of this project for Federal construction without prejudice to other non-Federal development of this site.

FEASIBILITY REPORT FOR HYDROPOWER

LOCKS AND DAM 1

MISSISSIPPI RIVER

ST. PAUL/MINNEAPOLIS, MINNESOTA

PERTINENT DATA

Normal upper pool (feet)	Elevation 725.1
Normal minimum tailwater (feet)	Elevation 687.2
Nominal lift (feet)	37.9
USGS gage number	05-2885
Location	Anoka, Minnesota
Gage drainage area (square miles)	19,100
Project drainage area (square miles)	19,680
Project pool area (acres)	4,128
Maximum flood flow (April 1965) (cfs)	91,000
Average flow (cfs)	7,600
Median flow (50 percent) (cfs)	5,200
Minimum flow (August 1976) (cfs)	529
Concrete spillway, crest length (feet)	574
Spillway crest (feet)	Elevation 723.1
Normal upper pool (with flashboards) (feet)	Elevation 725.1
Top of lock wall (feet)	Elevation 732.7
Flood crest, pool (April 1965) (feet)	Elevation 734.5
Flood crest, tailwater (April 1965) (feet)	Elevation 719.2

PROPOSED HYDROPOWER ADDITION

	Existing Installation	Alternative C
Site capacity (kW)	14,400	7,200
Dependable capacity (kW)	10,800	2,400
Plant factor (annual)	.65	.34
Average annual energy (MWh)	82,400	21,450
Investment first cost ($1,000)	-	11,607
Benefit-cost ratio (for addition)	-	1.11
Power production cost	-	48 mills/kWh

UNIT DESIGN PARAMETERS FOR ADDITIONAL UNIT

Number of units	One
Turbine type	Horizontal shaft turbines with adjustable propeller blades and wicket gates.
Generator type	Synchronous
Runner diameter	142 inches (3.6 meters)
Synchronous speed	133.33 rpm
Operational headrange	35 to 24 feet
Project design head	35 feet
Design flow (total maximum)	1,200 to 3,050 cfs
Generator nameplate capacity	7.2 MW
Turbine setting	Centerline elevation 682.0
Generator efficiency	95 percent
Intake invert elevation	693.6

FEASIBILITY REPORT FOR HYDROPOWER

LOCKS AND DAM 1

ST. PAUL-MINNEAPOLIS, MINNESOTA

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FEASIBILITY REPORT FOR HYDROPOWER
LOCKS AND DAM 1
MISSISSIPPI RIVER
ST. PAUL/MINNEAPOLIS, MINNESOTA

PROBLEM IDENTIFICATION

SCOPE OF THE STUDY

The work supporting the recommendations of this report represents feasibility level detail. This feasibility report is intended to:

- o Formulate a viable small hydropower project.
- o Determine the implementation strategy.
- o Provide the engineering, economic, and environmental basis for implementation.
- o Determine which hydropower project, if any, maximizes net benefits to the Nation.

Significant efforts were spent to define, investigate, and definitively assess the following project aspects:

- o Legal.
- o Institutional.
- o Engineering.
- o Environmental.
- o Power Marketing.
- o Economic and financial analysis.

A feasibility report is a decision document to determine whether a particular investment is in the Federal public interest. The findings of a feasibility investigation should determine whether a commitment to project implementation is warranted. If the finding is positive, the

feasibility study defines the steps needed to assure effective implementation.

A positive economic feasibility finding is normally necessary for further implementation. However, other concerns can be equally important in serving the broader public interest, and a feasibility study should be performed in the modern spirit of wise natural resource management and multi-objective planning principles.

This study encompasses the locale around locks and dam 1 on the Mississippi River. The entire bluff to bluff area across the dam was considered for powerhouse locations. Potential powerhouse operation effects were considered upstream as far as the lower At. Anthony Falls site and downstream to locks and dam 2. Plate 2 is a site plan, and plate 4 is an aerial photo of the existing conditions.

AUTHORITY

Study Authority

Recognizing the importance of continued and successful operation of completed projects, Congress provided the Corps with the authority to study possible modifications to existing projects. The study is being done under the authority contained in the House Committee on Public Works resolution, dated December 11, 1969, which requested the Corps of Engineers:

> ". . .to review the reports of the Chief of Engineers on the Mississippi River between Coon Rapids Dam and the mouth of the Ohio River. . . with a view toward determining whether any modifications of the existing project should be made at this time in the interest of providing increased flood control, and for allied purposes on the Mississippi River."

Because of the integral nature of the Corps of Engineers locks and dam 1 and the Ford Motor Company hydropower plant, the entire area bluff-to-bluff was considered for the hydropower addition.

Federal Project Construction Authority

Presently, there is no Congressional construction authorization for Federal construction of additional hydropower facilities at locks and dam 1. Congress could authorize construction of a Federal hydropower project at locks and dam 1 based on the findings in this report.

COORDINATION AND STUDY PARTICIPANTS

Agencies and interests were informed of the initiation of the study by mail in a notice dated October 29, 1982. A copy of the initial notice, the mailing list, and pertinent responses to the notice are on file at the St. Paul District Office.

Ford Motor Company, owner and operator of the existing hydropower facilities at locks and dam 1, provided data and reviewed the turbine technical report. The St. Paul District sincerely appreciates the cooperation and assistance provided by the Ford Motor Company and its St. Paul, Minnesota, vehicle assembly plant.

Other primary participants in the study include the Federal Energy Regulatory Commission (FERC), the U.S. Fish and Wildlife Service (FWS), and the St. Paul District of the Corps of Engineers. Under the Federal Power Act and other legislation, FERC has broad responsibilities related to planning, constructing, and operating water resource projects, particularly in regard to power development. One of those responsibilities is establishment of values for power and capacity that might be produced by a Federal project at locks and dam 1. Correspondence related to power value determination is in the turbine technical report in the appendix at the back of this report.

The U.S. Fish and Wildlife Service, under the authority of and in accordance with the Fish and Wildlife Coordination Act, is the primary agency from which the Corps of Engineers obtains Federal fish and wildlife resource data and planning input.

The St. Paul District, Corps of Engineers, is chiefly responsible for this study and report. This feasibility report may serve as an authorization document for approval by Congress. This report is distributed to all interested Federal and State agencies for comment prior to finalization. The report is also available to the public.

The Minnesota Department of Natural Resources participated in the environmental assessment. The agency provided useful data concerning the fishery present in the study area.

PRIOR HYDROPOWER STUDIES FOR THE LOCKS AND DAM 1 STUDY AREA

1. On March 3, 1910, a special commission reported to Congress concerning the use of surplus flows for power generation at the Twin Cities locks and dams. At that time, two low-head locks and dams were being considered in place of the present locks and dam 1. The commission recommended construction of the single high dam, as presently constructed, instead of two lower dams. In the commission's opinion, the high dam would better serve future navigation and would allow feasible hydropower development. The higher locks and dam 1 was completed in 1917 with the integral powerplant foundation. Ford Motor Company negotiated a lease with the Corps of Engineers to use the Federal facilities, and obtained a license from the Federal Power Commission in 1923. The Ford Motor Company's powerhouse and generation equipment became operational in 1924.

2. The Corps of Engineers Institute for Water Resources has completed the National Hydropower Study. Locks and dam 1 is one of the sites

investigated. The National Hydropower Study was authorized by Section 167 of the Water Resources Development Act of 1976 (Public Law 94-587). The study provided a general but comprehensive appraisal of the potential for increments of new hydropower generation at existing dams and other water resource projects as well as at undeveloped sites in the United States. Preliminary results of that study show apparent economic feasibility for additional hydropower at locks and dam 1.

3. The Corps of Engineers September 1981 reconnaissance report contained a preliminary evaluation of additional hydropower at the existing locks and dam 1. The study found that installation of new additional generation facilities with a 4MW (megawatt) or 8 MW nameplate rating would be economical.

4. Ford Motor Company reviewed the Corps of Engineers reconnaissance report dated September 1981. In a July 26, 1982, letter, Ford stated that the potential additional generation capacity would not be economically feasible for them at that time. The Ford Motor Company indicates that it has no current plans to expand their power generation facilities at locks and dam 1. General Electric Company has proposed an upgrade project for the existing Ford generators. Ford Motor has indicated some interest in General Electric's proposal to refurbish the existing turbines and generators.

5. The Department of Energy conducted a study in response to a request from the Chief of Engineers. Unlike most regions of the United States, there is no specific Federal power marketing organization that serves the Great Lakes area. The study examined the electric power requirements and resource potential of the Great Lakes area. The intent of the study is to provide information to the Corps and to potential customers on the hydropower potential and its marketability.

The report also shows that the development of hydropower on a regional basis as a system is more advantageous than the development of individual projects at random. A final report has not received final internal Department of Energy approval for distribution. However, data from the draft have been incorporated into this feasibility study.

6. The locks and dam 1 site is not eligible for the small hydropower feasibility studies loan program under Title IV of the Public Utility Regulatory Policies Act of 1978. The main reason for exclusion is that the site is currently licensed and is generating power (Ford Motor Company). Therefore, no proposals for additional hydropower development are likely to compete with either the Corps of Engineers and/or Ford Motor Company interests at the site.

THE REPORT AND STUDY PROCESS

Results of the feasibility study are contained in this report. The report consists of a main report, environmental assessment, and technical appendix, all contained in this one volume. The St. Paul District completed a reconnaissance level evaluation of the locks and dam 1 site in September 1982. The reconnaissance study concluded that increments of 4.0 and 8.0 MW of additional hydropower generation are feasible on a preliminary basis.

The feasibility study was initiated in October 1982. The final feasibility report for this study will be completed by September 1984. Authorization and funding by Congress are necessary before more detailed design work or the recommended construction action could be taken for Federal development of hydropower at locks and dam 1.

NATIONAL OBJECTIVE

The Federal objective that guided formulation of this project is expressed in the U.S. Water Resources Council Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (March 10, 1983):

- The Federal objective of water and related land resources planning is to contribute to national economic development consistent with protecting the Nation's environment pursuant to national environmental statutes, applicable exective orders, and other planning requirements.

- Contributions to national economic development (NED) are increases in the net value of the Nation's output of goods and services, expressed in monetary values.

- The Federal objective for the relevant planning setting should be stated in terms of an expressed desire to alleviate problems and realize opportunities related to the output of goods and services or to increased economic efficiency.

- Each statement of a pertinent water resource problem or opportunity should be expressed in terms of a desired output.

This Federal objective (as expressed in the new Principles and Guidelines) combines the previously coequal national economic development (NED) and environmental quality (EQ) objectives of the former Principles and Standards (P&S).

The social well-being and regional development values are also considered important, although to a lesser degree. Viable alternative solutions considered in this report have been evaluated and examined in light of the goals of increasing national and regional economic gains,

enhancing the quality of the human and natural environments, and improving social well-being.

EXISTING CONDITIONS

Existing Water Resource Projects at Locks and Dam 1

Locks and dam 1 is at Mississippi River mile 847.6 above the mouth of the Ohio River and between the cities of St. Paul and Minneapolis, Minnesota. The original structure was completed and placed in operation in 1917. It included a 152-foot-long hydroplant foundation adjacent to the left bank, a 574-foot crest-length, Ambursen-type dam surmounted by 2-foot-high automatic release flashboards and eight sluiceways (only three sluice gates are operated and maintained at the present time), and a navigation lock. In 1929 the lock failed, cutting off all barge traffic to Minneapolis. To insure against a future interruption to barge traffic, it was decided to build twin locks, each 56 by 400 feet, at this site. The first lock (riverward lock) was completed in 1930, and the second lock was placed in operation in 1932. The drawings on pages 12 and 13 show typical cross sections of the locks and dam.

The present riverward lock was built in 1929 and 1930 to replace the original lock that failed. The plan was to provide a structure suitable for 9-foot draft navigation based on the design pool level for lock and dam 2 which was then under construction. However, because of probable seepage damages, interests in the South St. Paul stockyards area in pool 2 (or tailwater of locks and dam 1) obtained a court order limiting the elevation to which the pool could be raised to 685.7 msl (mean sea level). Later, in 1934, the court approved the raising of the pool to elevation 687.2, 1.9 feet less than its designed height. As a result, there is a depth of only 7.5 feet over the lower sill at

flat pool or about 8 feet at normal tailwater elevation. The riverward lock is therefore used for locking pleasure boats, empty barges, or shallow-draft towboats.

Lock and Dam 1 - Tonnage of Commodity Movement

Year	Tonnage
1975	2,887,000
1976	3,062,000
1977	2,850,000
1978	2,114,000
1979	2,182,000
1980	2,162,000
1981	1,439,000
1982	1,413,000

The present landward lock was built in 1931 and 1932 as a safeguard to maintain river traffic to and from Minneapolis. As a result of the failure of the original lock, Minneapolis was without barge line service for over a year. It was determined that a recurrence should be avoided if at all possible. The downstream sill of this lock has a top elevation of 677.2, providing a depth of flat lower pool of 10.0 feet or about 10.8 feet at normal tail-water elevation; hence, this landward lock handles the majority of commercial traffic through this facility.

Anticipated traffic coupled with the continually deteriorating condition of the existing locks justified major rehabilitation work. Rehabilitation will extend the design life of the structure an additional 50 years. The Federal cost was $44,600,000, and there was no non-Federal cost. Construction was begun in 1978 and was completed June 1983.

The dam is an Ambursen-type concrete structure. For the greater part, it is supported on an alluvial fill consisting primarily of sand, gravel, and limestone slabs. A portion of the dam and apron, however,

is supported on timber piling. Along the upstream face of the dam is a steel sheet-pile cutoff wall. There is also a row of steel sheet-piling along the toe of the apron as a preventive measure against scour. The crest and the downstream face has been resurfaced (1949-53). A major portion of the apron has been replaced, and a baffle wall was constructed on the apron to induce a hydraulic jump to overcome serious scour below the dam. This work was completed in 1953. In 1952 the dam was stabilized by placing sand fill in the interior to reduce the possibility of failure by sliding. Three of the eight sluice gates in the dam were rehabilitated, and hydraulic machinery to operate them was installed in 1954. Under present pool conditions, the dam maintains a normal head of about 38 feet during the navigation season and about 36 feet during the winter season. In general, the dam is in good condition. During 1981 and 1982, the dam apron was repaired and post-tensioned anchors were installed to increase the stability. This work was done in conjunction with the locks and dam 1 rehabilitation project.

Existing Hydropower Facilities at Locks and Dam 1

The existing hydroelectric plant, located at the east end of the dam, and flashboards on the crest of the dam are maintained by Ford Motor Company. The powerhouse structure is 152 feet long, 74 feet wide, and 51 feet high. It has a reinforced concrete substructure and a stone superstructure with tile roof. The powerhouse contains four Francis-type turbines connected directly to the generators. Each turbine is set in a 10-foot 9-inch circle of wicket gates. Water is conveyed to the turbines directly from the forebay pool. The four generators have a total rating of 14,400 kW at an 80-percent power factor, but because of their condition, probably produce only about 13,000 kW maximum. The total hydraulic capacity of the units combined is about 6,670 cubic feet per second. The units operate under a normal maximum gross static head of 37.9 feet with the dam crest gates (flashboards) up.

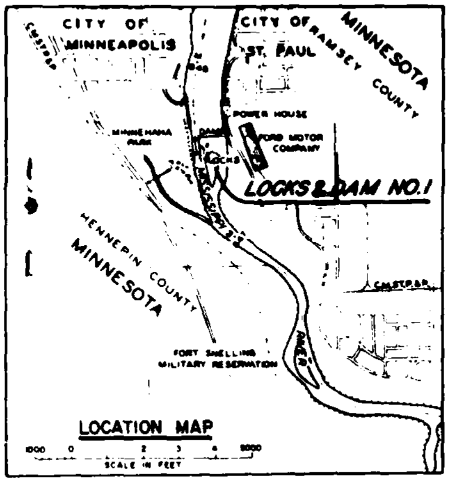
The plant generates at 13,800 volts and transmits current via underground cable to a substation that transforms it to 440, 220, and 110 volt current for factory distribution. About 40 percent of the generated current is consumed by the nearby Ford Automotive Plant. A total of 82,400 MWh (megawatt hours) is generated annually. Of this total, the Corps facility of locks and dam 1 uses 225 MW yearly. 60 MWh of energy are provided free of charge. The remaining 165 MWh hours are provided at a nominal charge in accordance with the licensing terms. Power not used by Ford or the Corps is sold to Northern States Power Company, an investor-owned utility.

Structural Integrity

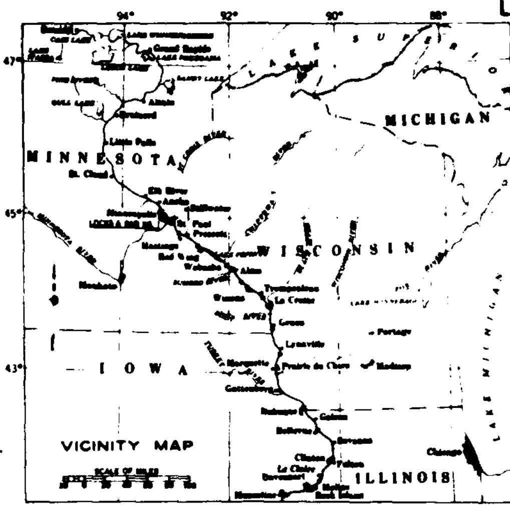
The stability and structural integrity of the powerhouse and the dam were evaluated in the latest periodic inspection report dated March 1978. Findings of that report indicate that the powerhouse was well maintained and in good condition. No remedial work was found to be required to ensure the integrity of the structure or its continued serviceability. The sliding factor of safety for the entire powerhouse was found to be 2.00. No remedial work is required to increase stability of the powerhouse.

The results of the analysis done in conjunction with the above report indicated that while the dam and sluiceway monoliths alone, without improvements, are stable, some improvement would be required to raise the sliding factor of safety to acceptable levels for the structure as a whole. The recommended alternative was to stabilize the aprons in such a manner that the combined dam/apron structure is adequately stable. This stabilization was done by installation of post-tensioned anchors through the apron.

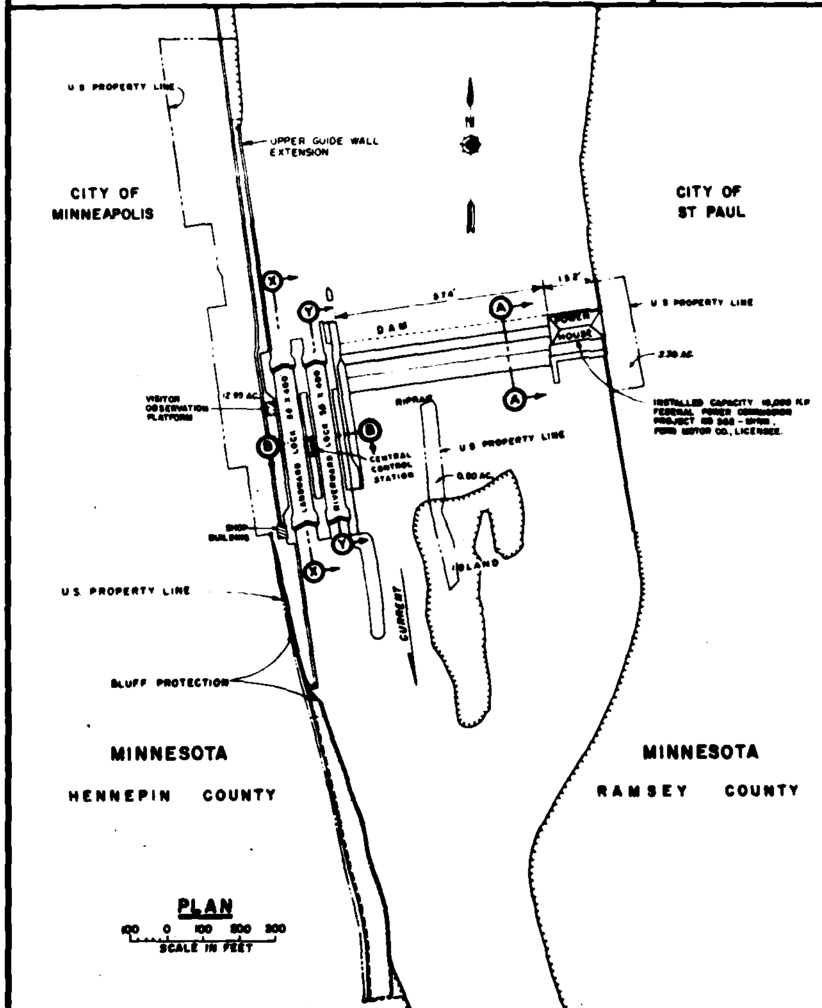
A major rehabilitation effort was recently completed for the existing locks. Current design criteria were used to evaluate modifications required to meet the standards, and the locks now meet or exceed current stability requirements.



LOCATION MAP



VICINITY MAP



PLAN

ELEVATIONS ARE REFERRED TO M.S.L. (1912 ADJ.)

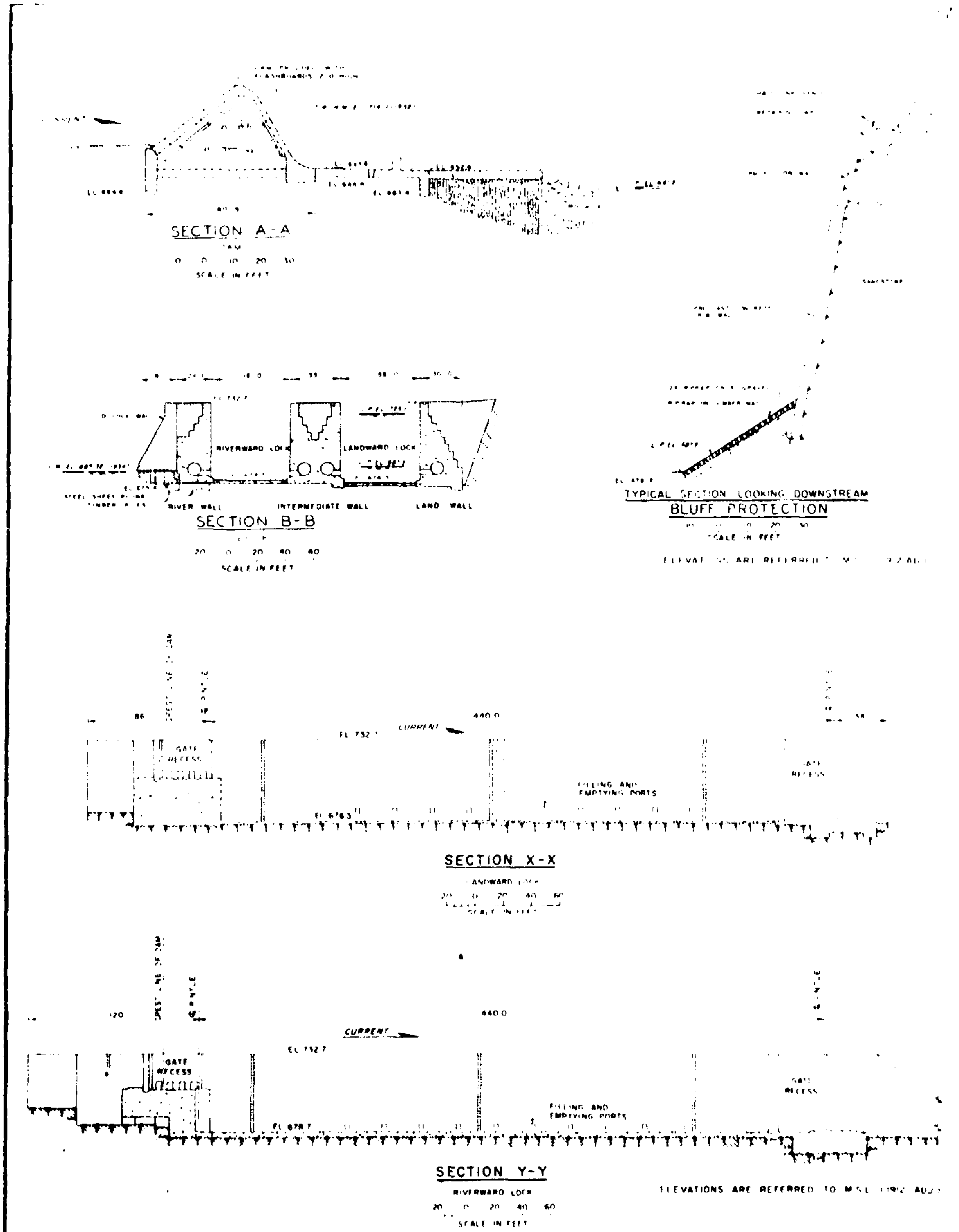
	RIVERWARD LOCK	LANDWARD LOCK
DEPTH ON UPPER GATE SILL	**13.4 FT. (U.P. EL. 723.1) * 12.4	13.4 FT. (U.P. EL. 723.1)
DEPTH ON LOWER GATE SILL	7.5 FT. (L.P. EL. 687.2)	10.0 FT. (L.P. EL. 687.2)
ELEVATION UPPER GUARD SILL	* 710.7	NONE
ELEVATION UPPER GATE SILL	709.7	709.7
ELEVATION LOWER GATE SILL	679.7	677.2

**POOL ORDINARILY MAINTAINED AT EL. 725.1 BY FLASHBOARDS.
*OLD UPPER GUARD SILL IN RIVERWARD LOCK ONLY

RIVER & HARBOR PROJECT
MISSISSIPPI RIVER
MISSOURI RIVER TO MINNEAPOLIS, MINN.

LOCKS & DAM NO. I

IN 2 SHEETS SHEET NO. I
SCALE AS SHOWN
CORPS OF ENGINEERS U.S. ARMY
OFFICE OF THE DISTRICT ENGINEER
ST. PAUL DISTRICT ST. PAUL, MINN.

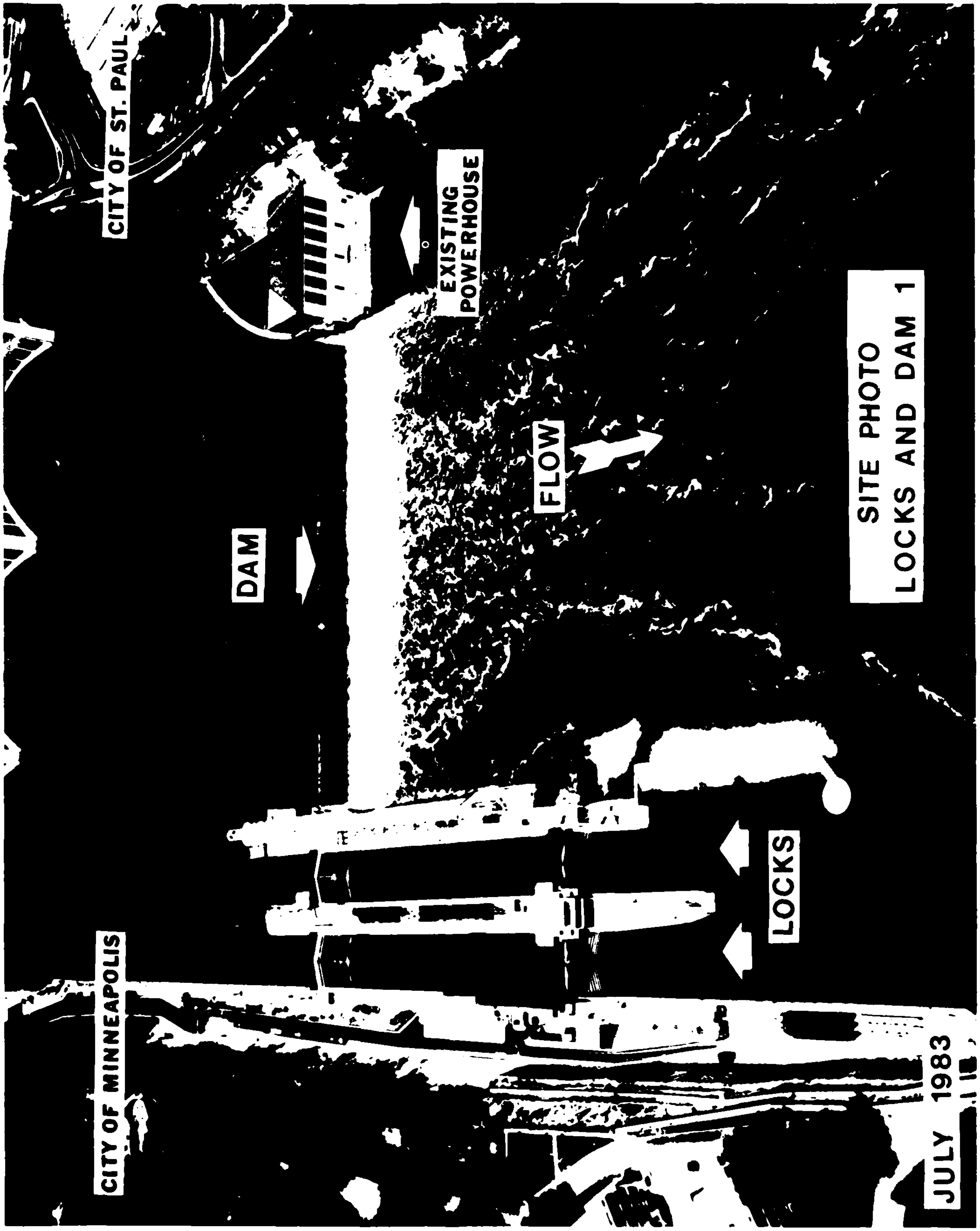


RIVER & HARBOR PROJECT
MISSISSIPPI RIVER
MISSOURI RIVER TO MINNEAPOLIS, MINN.

LOCKS & DAM NO. 1

IN 2 SHEETS — SCALE AS SHOWN — SHEET NO. 2

CORPS OF ENGINEERS — U.S. ARMY
OFFICE OF THE DISTRICT ENGINEER
ST. PAUL DISTRICT — ST. PAUL, MINN.


CITY OF ST. PAUL
EXISTING POWERHOUSE
DAM
FLOW
SITE PHOTO
LOCKS AND DAM 1
CITY OF MINNEAPOLIS
LOCKS
JULY 1983

Existing Power Grids

Data in the Department of Energy Marketing Report for the Great Lakes area indicate that a 50-mile radius area around locks and dam 1 contains portions of 2 investor-owned, 11 cooperative, and 16 municipally-owned electric utility service areas, all in two States, Minnesota and Wisconsin. The existing Ford Motor Company hydropower plant sells excess generation to Northern States Power (NSP). NSP, an investor-owned utility, is by far the largest utility within the 50-mile radius, with a 1983 wintertime generation commitment of about 8,200 MW. All other electric utilities within the 50-mile radius could provide about another 2,000 MW combined.

About 60 percent of the existing generating capacity within this area is coal generated, 20 percent nuclear, and about 20 percent gas-oil generated.

The proposed hydropower station at locks and dam 1 would be capable of producing only about one-tenth of 1 percent of the existing capacity of the 29 utilities mentioned above. Including the capacity of the proposed St. Anthony Falls hydropower plant, which is 5 miles upstream, the capacity being proposed would be only four-tenths of 1 percent of the existing capacity. The proposed hydropower capacity would have minimal impact on the overall system.

In comparison, the locks and dam 1 or St. Anthony Falls hydropower facilities could provide a larger percentage of the electrical needs of the individual municipal and cooperative (preference) customers. The combined capacities of the proposed St. Anthony Falls and locks and dam 1 hydropower plants could provide about 2.8 percent of the identified municipal and cooperative capacities. The relative efficiencies of hydroelectric generation would permit the sale of power at a competitive rate or at a lower rate than currently being paid to the investor-owned utilities. This savings in cost would be passed on

to customers of municipal and cooperative-type utilities or to the general public as decided by the Department of Energy.

Hydropower plants are also being considered at locks and dams 2, 5, 5A, 6, 7, 8, 9, and 10 by either the Corps or non-Federal groups. Although none of these proposed hydroelectric projects are capable of producing enough power to have a significant impact on the existing power grid, they are capable of supplying a significant percentage of the power needs of individual preference customers.

Hydrologic Power Evaluation

The flow available for hydropower at locks and dam 1 is estimated from 49 years of data from the gage at Anoka, Minnesota (USGS 05-2885). This gage is at river mile 864.8 from the mouth of the Ohio River, and is 17.2 miles upstream of locks and dam 1. The total drainage area upstream of the project is 19,684 square miles, which is 3.1 percent greater than the area upstream of the gage. There are no major tributaries between the gage and the project site. The additional drainage area between the gage and the project site is ignored in this hydrologic power evaluation. The small additional discharge from that area roughly equates to withdrawals at Minneapolis.

The average monthly flows at Anoka, Minnesota, are shown in the table below:

Average Monthly Flows, Mississippi River at Anoka, Minnesota

Month	Flow (cfs)	Month	Flow (cfs)
January	3,800	July	7,900
February	3,700	August	5,700
March	6,400	September	5,200
April	17,100	October	5,400
May	14,500	November	5,500
June	11,200	December	4,200
Annual Average Flow:	**7,600**	**Median Flow:**	**5,200**

The production of power from the force of falling water follows from basic principles of physics. Work (energy) can be expressed as a force moving through a distance:

$$E = \text{Force} \times \text{Distance} \qquad \text{(lb-ft)}$$

In the case of hydropower production, the force is the weight of the water, and the distance is the vertical fall, or "head," which is the difference between pool and tailwater elevations.

$$E = F \times D = (\text{unit weight of water}) \times (\text{volume of water}) \times (\text{net head})$$

$$E = {}_{w} \cdot (V) \cdot (H) = 62.4 \cdot (V) \cdot (H) \qquad \text{(lb-ft)} \qquad (1)$$

Power is the rate at which the energy is produced. If the head is presumed constant over a short interval, then the power available is:

$$P_a = \frac{dE}{dt} = 62.4 \times \frac{dV}{dt} \times H = 62.4 \cdot Q \cdot H \qquad \frac{\text{ft-lb}}{\text{sec}} \qquad (2)$$

where Q represents the flow in cfs.

Expressed as horsepower: (1 HP = 550 ft-lb/sec)

$$P_a = \frac{62.4}{550} \times Q \times H = \frac{(Q)(H)}{8.81} \qquad \text{(HP)} \qquad (3)$$

or as kilowatts: (1 HP = .746 kW)

$$P_a = \frac{Q \times H}{8.81} \times .746 = \frac{(Q)(H)}{11.82} \qquad \text{(kW)} \qquad (4)$$

To take into account the efficiency of the machine, a factor "e" is added to the equation for each "transfer point" in the process:

e_t = turbine efficiency

e_m = speed increaser efficiency

e_g = generator efficiency

$e = e_t \times e_m \times e_g$

and the net power is $P_{net} = \dfrac{Q : W : e}{11.82}$ (5)

For preliminary calculations involving modern machinery, an average overall efficiency of about 0.86 is often used. Then:

$$P = \frac{(Q)(H)(0.86)}{11.82} = \frac{(Q)(H)}{13.7} \quad \text{(kW)} \qquad (6)$$

Power is the rate of production of energy, so the total energy produced in a given period is found by multiplying the average power during the period, in kilowatts, by the length of the period in hours.

$$E = \text{power (kW)} \times \text{time (hours)} = \text{kilowatt-hours (kWh)} \qquad (7)$$

Sometimes energy is expressed as megawatt-hours (MWh) or gigawatt-hours (GWh):

1 MWh = 1,000 kWh

1 GWh = 1,000,000 kWh

Since the flows at a given site are usually quite variable, it would be useful to store excess volumes for use during lower flow periods. The St. Paul District's navigation dams have only minimal storage available (pondage). For several reasons, including navigation, wildlife environment, recreation and business interests, pool fluctuations are

kept to a minimum; and, without pool fluctuations, the useful storage is negligible. The pool above locks and dam 1 does not provide significant storage for peaking operation.

A number of other factors affect the amount of potential generation capacity at this site. For more detailed information, turn to the appendix (see section 3 of that report) containing the technical report from the Corps' hydroelectric design center at Portland, Oregon.

ENVIRONMENTAL SETTING

Terrestrial Resources

Locks and dam 1 is situated in the Mississippi River gorge or valley. The sandstone and limestone bluff at the dam is about 95 feet above the surface of pool 1. The bluff tops are approximately 1,200 feet apart at the dam.

The climate is humid-continental with severe winters. Normal precipitation is approximately 26 inches, of which 65 percent falls from May to September. Mean annual snowfall is about 41 inches, and 70 percent of the snowfall occurs from December through March.

The slopes and bluff adjacent to the dam are vegetated with a mixture of typical river slope and upland woody species. The island below the dam supports the remnant of a young floodplain forest stand. The southern half of the island is largely covered with trees and shrubs including green ash, cottonwood, and willow. The northern half of the island is covered mostly by grasses and wildflowers.

The island is utilized by turtles, migrating birds, and nesting birds including waterfowl, shorebirds, and songbirds. Terrestrial habitat is otherwise limited by the steep bluff slopes. The small area, low

vegetation, and spring flooding would discourage mammals from colonization.

Aquatic Resources

Forty-seven species of fish have been found in pool 1. Common species include gar (2), bowfin, white sucker, bigmouth buffalo, catfish (2), white and rock bass, largemouth bass, black and white crappie, yellow perch, sauger, walleye, freshwater drum, and several forage species. There is some sport fishing but no commercial fishing in the study area.

The quality of water passing over locks and dam 1 is generally good but may be degraded by the occasional overflow of the sanitary and storm sewers. Dissolved oxygen levels are high, often exceeding saturation because of aeration at St. Anthony Falls and locks and dam 1. The Minnesota Department of Natural Resources has advised against eating more than one meal of fish per week from the river in this area. The warning was prompted by the bioaccumulation in fish of heavy metals, polychlorinated biphenyls (PCB's), and chlorinated hydrocarbons (pesticides).

Recreation

Current recreational use of the study area consists of general boating, fishing, day-use activities, and sightseeing. Substantial sport fishing is done below the locks and dam. Much of the day-use activity centers around Minnehaha Park in Minneapolis. This city-owned park includes a trail system that follows Minnehaha Creek down to a point on the Mississippi River just downstream of locks and dam 1.

Cultural Resources

The location of locks and dam 1 in the Twin Cities and the activities surrounding this area severely limit the potential for prehistoric archeological remains. However, a number of significant historic resources are located in the area. The Minnesota Soldiers Home (determined eligible for the National Register of Historic Places) and the Minnehaha Park Historic District (listed on the National Register of Historic Places) overlook locks and dam 1 from the western bluffs of the Mississippi River. South of these sites, Fort Snelling, another National Register property, is located at the confluence of the Mississippi and Minnesota Rivers. The site most directly affected by the proposed hydropower development, however, is the locks and dam structure itself.

Locks and dam 1 remained the northernmost structure in the Upper Mississippi River Federal navigation system until the construction of the locks at St. Anthony Falls in the early 1960's. Locks and dam 1 was the first structure of the Upper Mississippi River Federal navigation system that was built, and it is the only one that was originally authorized for both navigation and hydropower. It and the St. Anthony Falls dams are the only dams within the St. Paul District portion of the 9-foot channel project that have existing hydroelectric power production. Locks and dam 1 is also the only fixed dam on the Upper Mississippi River.

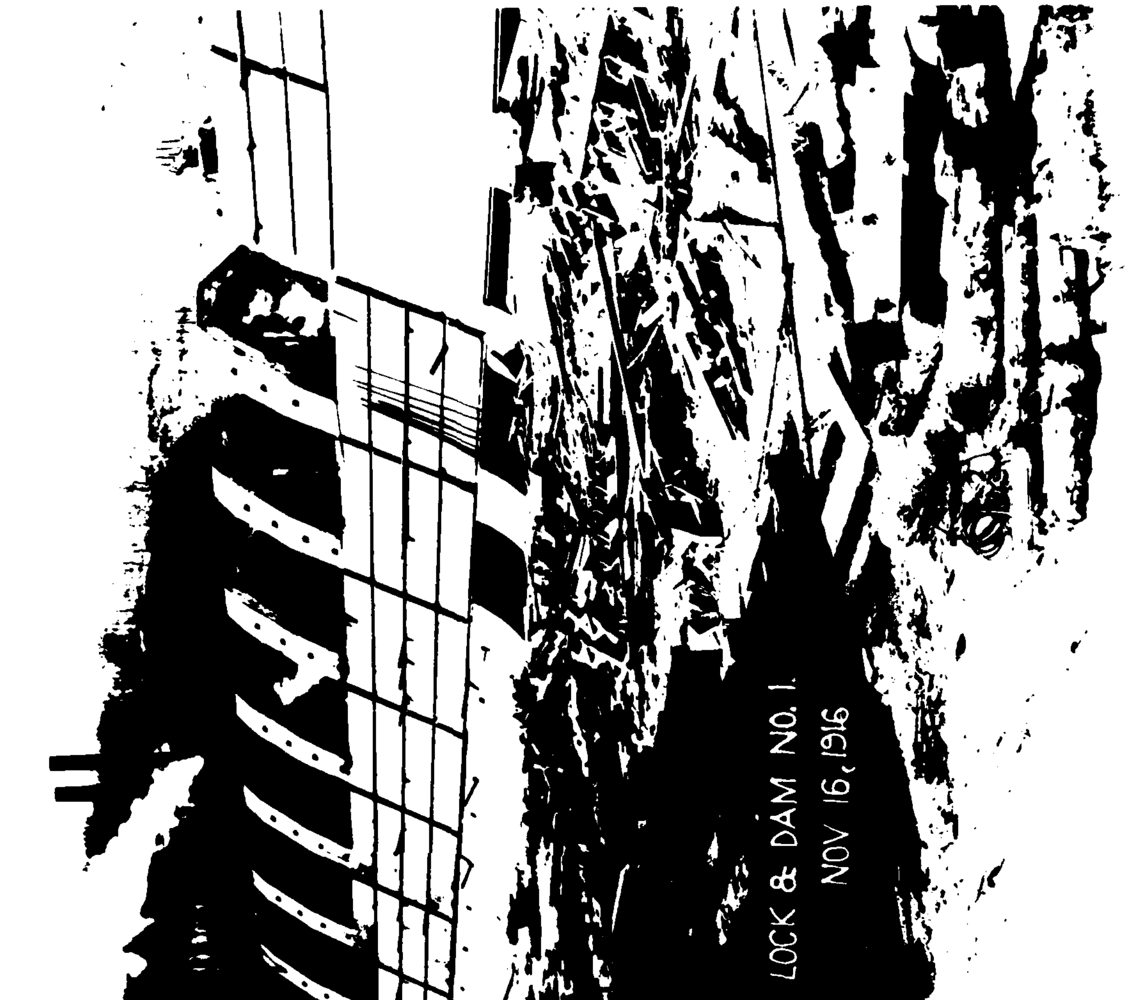
The construction history for locks and dam 1 spanned the period between 1894 and 1932 (see Gjerde, 1983: 122-125). Completion of the original lock, dam, and powerhouse on June 30, 1917, began a 12-year period of lock operation that ended on August 19, 1929, when the lower gate of the lock collapsed. Navigation was not restored until September 30, 1930; and by 1932 an additional lock was completed to prevent further disruption to navigation.

Locks and dam 1 was designed by Major Francis R. Shunk of the U.S. Army Corps of Engineers. The dam itself was built as a modified form of the new Ambursen type dam. It is a hollow structure with a deck of narrow reinforced concrete slabs overlying a triangular concrete buttress (see Plate 9 and the following photo dated November 16, 1916. The concrete dam was constructed using both cast-in-place and mold-casting methods. The dam is 574 feet long with a 152-foot-long foundation for the powerhouse. The 30-plus-foot head at locks and dam 1 allowed Major Shunk to become the first officer of the Corps of Engineers to design and build a hydroelectric dam in the United States (Gjerde, 1983: 121). Because the Federal Government was not interested in hydroelectric generation, powerhouse construction was not carried further than the foundation. By 1912, a consortium was formed by the cities of Minneapolis and St. Paul and the University of Minnesota to negotiate with the Government for the rights to develop the locks and dam 1 site. The Federal Power Commission ultimately assigned these rights to the Ford Motor Company, with a maximum capacity of 18,000 horsepower. By July 1924, four 4,500-horsepower generators had been installed and were in operation.

A detailed discussion of the impacts of the proposed hydropower development can be found in the environmental assessment.

Demographic Setting

Locks and dam 1 is within the Minneapolis-St. Paul SMSA (Standard Metropolitan Statistical Area). The population of Minneapolis-St. Paul SMSA was about 1.8 million in 1970 and is projected to grow to about 2.7 million by 2,000. Major employment catagories include manufacturing, wholesale and retail trade, and households and services.


LOCK & DAM NO. 1
NOV 16, 1916

NEED FOR HYDROPOWER

The need for hydropower is reflected in a market analysis that determines society's willingness to pay for it. Generally, society desires hydropower because it is relatively cheap and because it relieves our dependence on foreign oil and other nonrenewable energy sources.

In response to a Corps of Engineers request, the Department of Energy (DOE) produced a power marketing report, dated 1981, for hydropower in the Great Lakes area. The study area described in the DOE report includes locks and dam 1 on the Mississippi River. The Federal planning process specified in the Principles and Guidelines requires determination of present and future needs and opportunities of water related resources such as hydropower. The DOE report serves as a basis for identifying present and future needs for hydropower as a water resource. After coordination of this draft report, the Department of Energy, Washington, D.C., office, will provide a letter describing marketability of federally-generated electricity at this particular site.

Conclusions of DOE Marketing Analysis

The 1981 power marketing report done by DOE provided a preliminary review of electrical power marketing in the Great Lakes area. It revealed that about 2.6 million kilowatts (kW) of hydroelectric capacity could be installed at dams now operated by the Corps of Engineers in the area comprising all of the States of Illinois, Indiana, Michigan, Ohio, and Wisconsin and parts of Iowa, Minnesota, Pennsylvania, and West Virginia. After allowing for sharing the output of plants that are on the border of adjacent power market areas, more than 2 million kW would still be available to help meet electric loads of the nine-State area.

Hydroelectric power developed at existing Federal dams could be used readily by the municipal and cooperatively owned utilities of the area. Those publicly-owned utilities are given preference by law in the marketing of Federal power. A study of preference utilities in the Great Lakes area shows that their current loads total almost 10,000 MW - five times the potential hydroelectric generating capacity of the area. Even with a modest load growth of 3 percent annually, the loads of preference customers by the year 2010 would be more than seven times the potential hydroelectric resources.

The study supports the general conclusion that the hydroelectric potential at existing navigation and flood control projects in the Great Lakes area could be readily marketed. Federal power generated at these projects would be marketed by the Department of Energy under provisions of the Flood Control Act of 1944. A recent sampling of the attitudes of specific preference customers in Iowa, Illinois, Indiana, Ohio, Michigan, and Wisconsin discloses that they are willing to commit themselves now to the purchase of such generation based on preliminary estimates of power costs developed by the National Hydroelectric Power Study. Development of this renewable resource could help reduce the energy needs of the area and significantly reduce the Nation's dependence on foreign oil - up to 20,000,000 barrels of oil annually. It is evident from the DOE study that the hydroelectric potential of the Great Lakes area is sufficiently attractive that further study is warranted - whether by Federal and/or non-Federal entities.

Role of Area Hydropower

The role of hydropower in the geographical area encompassing Upper Mississippi River navigation dams of the St. Paul District can best be explained by referring to the National Hydropower Study (NHS). The study was accomplished by the Corps of Engineers Institute for Water Resources (IWR) during the period 1978-1980. The Electric Reliability Council Regions provided data for the NHS.

Electric power systems are divided into nine Electric Reliability Council Regions in the United States. The navigation dams in the St. Paul District are presently all in the Mid-Continent Area Power Pool (MAPP) system, which assumed all of the former Mid-Continent Area Reliability Council Agreement (MARCA) responsibilities in 1982. However, the NHS was conducted while MARCA organization was still in effect. Both MAPP and the former MARCA cover a 400,000-square-mile area in the United States that includes all of Minnesota and the western half of Wisconsin plus Iowa, North Dakota, South Dakota, Nebraska, and eastern Montana. The Canadian Provinces of Manitoba and Saskatchewan are associate members of MAPP.

The MARCA Council was originally organized in 1968, and membership consisted of 22 larger electrical systems. There were, and still are, 11 investor-owned systems, 8 generating transmission cooperatives, 2 public power districts, and a Federal agency in the council region. The purpose of the council region is to enhance electric reliability of the region and to effectively use the combined resources of the member systems in the event of an emergency in one of the systems.

The following extract from volume XIX of the September 1981 NHS Regional Assessment clearly presents the role of hydropower in the former MARCA (MAPP) region.

ROLE OF HYDROPOWER WITHIN THE EXISTING SYSTEM

> Conventional hydropower currently plays an important role in the MARCA generation system. About 12.2 percent of the total 1979 summer generating capability was provided by hydropower. As of January 1, 1979, there were 57 hydropower plants in the MARCA system. The plant capabilities range from less than 1 MW to more the 650 MW. The majority of MARCA hydropower facilities provide a capability of less than 30 MW each. However, there are eight large Federal hydropower plants which provide approximately 84 percent of the MARCA hydropower capability. Of the eight Federal hydropower plants, six located on the Missouri River were constructed and are operated by the Army Corps of Engineers. The remaining two are Water and Power Resources Service projects -

one on the Missouri River and one on the Big Horn River. . . . . About 84.2 percent of the total MARCA hydropower generating capability is located within the Dakotas and Montana with the remaining 11.6 percent, 4.1 percent, and 0.1 percent located in Minnesota-Wisconsin, Nebraska, and Iowa, respectively.

There are no hydropower additions or retirements scheduled for MARCA during the 1979-1988 period;(1) however, a slight decline in hydropower capacity during this period is projected. This reflects the conservatism in forecasts which anticipate future water supplies and capacity to be less than experienced in the good water year of 1978.

Magnitude

According to utility reports, the 1979 summer hydropower capability was 2970 MW. The total 1978 hydropower generation in the MARCA area was 15,495 million kilowatt-hours, representing 16.5 percent of the total MARCA net generation. Utilities indicate by 1988, hydropower generation is expected to decline to 7.5 percent of the net total, or 12,074 million kilowatt-hours. Table 3.6 shows the expected decline, according to utility forecasts, in hydropower generation in comparison to the MARCA total through the 1978-1988 period. Hydropower capability is expected to decline from 2970 MW or 12.2 percent of MARCA total, in summer 1979 to 2790 MW or 8.5 percent in the summer of 1988. The 206 MW reduction occurs entirely within the Dakotas-Montana subarea. These projections are predicted on estimated future water supply and do not reflect less hydroelectric machinery.

Table 3.6
HYDROPOWER GENERATION PROJECTIONS 1978-1988
(Millions of Kilowatt-Hours)

	Generation	Percent of MARCA Net Generation
1978 (Actual)	15,495	16.5
1979	13,902	13.2
1980	13,174	11.9
1981	12,922	11.0
1982	12,972	10.2
1983	12,972	10.1
1984	12,974	9.7
1985	12,072	8.6
1986	12,072	8.2
1987	12,072	7.7
1988	12,074	7.5

(1) There were no hydropower additions contemplated for the MARCA area at the time this article was written for MARCA. However, the recent renewal of interest in hydropower has resulted in proposed hydropower projects at a number of sites.

Type of Energy

The Federal hydropower plants in MARCA except Gavins Point can be operated essentially as peaking or intermediate plants fully integrated with the base loaded thermal plants in the area.

Gavins Point is generally base-loaded to provide steady flows for navigation. The marketing agent purchases off peak energy from thermal resources to meet off peak demands of their customers. The hydropower resources are concentrated on peak to

meet firm loads and to replace generation by high cost oil in the MARCA area. Other hydropower plants in the MARCA area are relatively small and essentially are run-of-river providing thermal replacement capacity and energy as river flows make them available.

The MARCA/MAPP Council is a summer peaking system and is expected to remain that way in the future. Within MARCA/MAPP, utilities have annual load factors varying between 50 and 66 percent. Future annual load factors are expected to average 57 percent.

Identification of Potential Preference Power Customers

The term "perference customer" is derived from wording in Section 5 of the Flood Control Act of 1944 (Public Law 78-534). This law states that it is "preferred" to distribute the federally-produced power to public utilities rather than to private utilities. The law is intended to provide a widespread public benefit from the relatively cheaper hydro-produced electricity.

The most likely preference purchasers of federally-produced power at locks and dam 1 would be one of the 16 municipal utilities or the 11 electric cooperatives with service areas falling within a 50-mile radius of the dam. These potential users are listed on the following table. The table includes the number of customers they serve and other data. This table shows that seven preference utilities are capable of generating all of their peak power needs. However, all of these utilities depend on diesel fuel for at least part of their generation.

Potential Preference Customer Data[1]

Utility	Number of customers	Peak demand (MW) Summer	Peak demand (MW) Winter	Power purchased (MWh)	Energy sales (MWh)	Capacity resources (MW)	Diesel gen (MW)
			MINNESOTA				
Municipalities							
Anoka	7,096	30.4	23.5	128,400	118,800	0	0
Arlington	790	2.9	2.0	11,900	109,780	0	0
Buffalo	1,859	6.8	5.7	28,490	25,300	0	-
Chaska	2,476	13.5	8.2	52,400	47,600	0	-
Delano	1,050	3.4	3.3	12,700	13,900	4.8	4.8
Elk River	2,167	7.7	8.2	29,000	40,300	9.1	9.1
Glencoe	1,936	12.6	13.1	30,100	41,980	21.1	21.1
Kenyon	1,114	2.3	2.1	9,341	9,760	1.9	1.9
Le Sueur	1,620	9.6	6.3	35,800	33,950	3.3	3.3
New Prague	1,230	7.8	6.1	18,900	36,800	11.9	11.9
North St. Paul	4,887	14.6	10.3	55,640	48,400	0	-
Princeton	1,356	3.4	3.4	16,185	14,500	0	0
Shakopee	3,544	15.1	10.4	57,600	54,100	0	0
Cooperatives							
Anoka	40,123	120.3	111.1	533,040	500,900	0	0
Cooperative Power Assoc.	0	0	0	0	0	16.8	16.8
Faribault County	1,339	4.6	5.9	23,180	21,020	0	0
Goodhue County	3,402	11.6	15.8	65,500	60,600	0	0
McLeod County	5,046	18.4	22.7	98,400	89,960	0	0
Minnesota Valley Electric	10,412	34.0	37.1	169,990	154,300	0	0
United Power	0	0	0	0	0	309.8	23.3
Wright-Hennepin	16,610	41.1	49.7	215,100	202,000	0	0
Minnesota total	108,057	360.1	344.9	1,591,666	1,623,950	378.7	92.2
			WISCONSIN				
Municipalities							
Centuria	365	0.7	0.9	4,040	3,710	0	-
New Richmond	1,858	7.4	6.5	33,900	32,300	0	0
River Falls	2,914	10.8	10.6	47,000	52,500	13.1	12.7
Cooperatives							
Pierre-Pepin	4,186	9.7	15.2	107,990	101,850	0	0
St. Croix County	3,946	13.3	18.1	75,900	71,100	0	0
Wisconsin total	13,269	41.9	51.3	268,830	261,460	13.1	12.7
Grand total	121,326	402.0	396.2	1,860,496	1,885,410	391.8	104.9

(1) Power Marketing, Great Lakes Area, U.S. Department of Energy, January 1981, Appendix A (50-mile radius).

The power generated by a hydroelectric facility at locks and dam 1 could be used to make up a portion of the deficit capacity experienced by preference customers as well as to replace the need for others to burn expensive diesel fuel. The city of Shakopee has already expressed an interest in hydropower at locks and dam 2 on the Mississippi River.

Although power can be sent several hundred miles over an interconnected grid system to many additional potential preference utilities, the municipal and cooperative utilities listed in the following table are capable of using all the power that could be generated by the locks and dam 1 power facility. Consequently, only those probable power purchasers are identified, although many of the other electric cooperatives and municipal utilities in Minnesota and Wisconsin could become the ultimate consumers.

Preference Customer Service Area

The city of North St. Paul is closest to the potential hydropower site while the communities of LeSueur, Arlington, Glencoe, and Kenyon are located approximately 50 miles south and west of the site. Eight of the 16 communities are primarily rural: Kenyon, New Prague, LeSueur, Arlington, Glencoe, and Princeton, Minnesota, plus Centuria and New Richmond, Wisconsin. River Falls, Wisconsin, is a rural university community; and Delano, Buffalo, and Elk River, Minnesota, can be classified as suburban fringe communities. North St. Paul is the sole urban potential preference customer; and Chaska, Shakopee, and Anoka are primarily suburban communities.

The Context for Socioeconomic Changes Among Potential Preference Customers

Socioeconomic data pertaining to these communities reflect three national trends begun in the 1950's and 1960's. The first concerns the out-migration of the young and upwardly mobile from urban to suburban

and suburban fringe areas, and the second relates to the out-migration of the young from rural areas to urban and university communities. The cumulative effects of these factors have contributed to high growth rates in suburban communities while urban and rural areas have remained relatively stable; some experiencing population loss and others minor to moderate increases. Therefore, when compared to urban and rural areas, the population in high-growth areas is characteristically younger and incomes tend to be higher. The third trend reflects the increase in small and medium-sized industry locating in rural areas because of tax incentives and the availability of less costly labor. As a result, the primary agricultural economic base, characteristic of rural areas, has been transformed to a mixed economic base.

During the decade of the seventies, growth in population and housing among potential preference customers was greatest in the suburban and suburban fringe communities (see the table on the following page). The population of Chaska increased by 92 percent and the number of housing units increased by 134 percent. In Elk River, housing and population increased by over 200 percent. Substantial growth also occurred in other suburban and suburban fringe communities.

In contrast, the rural communities of Arlington and Kenyon and urban North St. Paul experienced slight decreases in population. Minor changes in population occurred in Glencoe, LeSueur, and New Prague while moderate increases in population occurred in Princeton and River Falls, Wisconsin. River Falls and Princeton also had substantial increases in the number of new housing units during the decade of the seventies: 47 and 42 percent, respectively. The remaining rural potential preference customers in Minnesota experienced minor increases in the number of housing units, and Centuria and New Richmond experienced moderate growth in housing (see the following table).

Population Estimates and Number of Housing Units, by Potential Preference Customer

		Population				Housing Units		
Municipality	County	1960	1970	1980	% Change	1970	1980	% Change
Minnesota								
Anoka	Anoka	10,562	13,298	15,634	17.6	3,910	5,520	41.2
Arlington	Sibley	1,601	1,823	1,779	-2.4	638	731	14.6
Buffalo	Wright	2,322	3,275	4,560	39.2	1,055	1,746	65.5
Chaska	Carver	2,501	4,352	8,346	91.8	1,327	3,099	133.5
Delano	Wright	1,612	1,851	2,480	34.0	576	869	50.9
Elk River	Sherburne	1,763	2,252	6,785	201.3	708	2,193	209.7
Glencoe	McLeod	3,216	4,217	4,396	4.2	1,413	1,720	21.7
Kenyon	Goodhue	1,624	1,575	1,529	-2.9	617	687	11.3
LeSueur	LeSueur	3,310	3,745	3,763	0.5	1,255	1,446	15.2
New Prague	LeSueur/Scott	2,533	2,680	2,952	10.1	886	1,133	27.9
North St. Paul	Ramsey	8,520	11,950	11,921	-0.2	3,261	4,061	24.5
Princeton	Mille Lacs	2,353	2,531	3,146	24.3	902	1,279	41.8
Shakopee	Scott	5,201	6,876	9,941	44.6	1,878	3,326	77.1
Wisconsin								
Centuria	Polk		632	711	12.5	226	302	33.6
New Richmond	St. Croix	3,315	3,707	4,306	16.2	1,223	1,665	36.1
River Falls	Pierce/St. Croix	4,859	7,238	9,036	24.8	1,835	2,694	46.8

The rural communities are also characterized by higher median ages and lower median family incomes (see the following table). The median age in Kenyon is 45.3, and the lower and upper bounds of median family income are $15,833 and $17,615, respectively. In contrast, Chaska, Elk River, and Shakopee have the lowest median ages and the highest median incomes. River Falls is an exception, however, because the low median age can be attributed to the university student body.

Median Age and Median Family Income, by Potential Preference Customer

Municipality	County	Median Age	Median Family Income Lower Bound	Median Family Income Upper Bound
Minnesota				
Anoka	Anoka	27.4	$21,444	$23,672
Arlington	Sibley	35.3	16,598	18,447
Buffalo	Wright	30.8	18,630	22,695
Chaska	Carver	26.2	21,731	24,721
Delano	Wright	27.5	19,171	21,259
Elk River	Sherburne	26.9	21,696	25,154
Glencoe	McLeod	33.0	17,790	20,776
Kenyon	Goodhue	45.3	15,833	17,615
LeSueur	LeSueur	32.8	19,742	23,627
New Prague	LeSueur/Scott	36.6	18,692	20,956
N. St. Paul	Ramsey	27.2	22,960	25,185
Princeton	Mille Lacs	29.9	15,036	19,740
Shakopee	Scott	26.7	22,488	25,133
Wisconsin				
Centuria	Polk	33.5	15,011	19,029
New Richmond	St. Croix	29.6	18,122	20,961
River Falls	Pierce/St. Croix	22.4	19,880	22,449

Source: U.S. Bureau of the Census.

Compared to the suburban and fringe suburban communities, the rural communities tend to exhibit a greater number of manufacturing employees per capita (see the following table). The number of manufacturing employees per capita in Princeton, Kenyon, New Prague, Glencoe, and LeSueur exceeds the number in the urban and suburban communities of North St. Paul, Buffalo, Delano, and Shakopee. Manufacturing firms in

the rural communities tend to use a significant percentage of the total municipal utility kWH deliveries. For example, the LeSueur Foundry, Creamery, and Green Giant combined used approximately 48 percent of LeSueur's total kWH deliveries in 1981 as indicated in the table on the following page. Green Giant also used 22 percent of Glencoe's deliveries. Forty-six percent of New Prague's total deliveries were consumed by International Multifoods, and 15 percent of Kenyon's were used by the Folderaft Company. If, in the future, one of the rural public utilities became the sponsor of a Federal hydropower project, then documentation would be required to determine if benefits from the project would be equitably distributed.

Manufacturing Base by Potential Preference Customer

Municipality	County	Number of Manufacturing Firms	Persons Employed in Manufacturing	Manufacturing Employees Per Capita
Minnesota				
Anoka	Anoka	4	2,555	.16
Arlington	Sibley	3	95	.05
Buffalo	Wright	4	215	.05
Chaska	Carver			
Delano	Wright	5	252	.10
Elk River	Sherburne	6	510	.07
Glencoe	McLeod	2	706	.16
Kenyon	Goodhue	2	320	.21
LeSueur	LeSueur	3	530	.14
New Prague	LeSueur/Scott	3	543	.18
N. St. Paul	Ramsey	3	342	.03
Princeton	Mille Lacs	3	712	.23
Shakopee	Scott	5	866	.09
Wisconsin				
Centuria	Polk			
New Richmond	St. Croix	3	725	.168
River Falls	Pierce/St. Croix		513	.056

Source: U.S. Bureau of the Census - 1960, 1970, 1980.

Percent Use of Total kWH Deliveries by Utility and Customer, 1981

Utility Name	Total kWH Deliveries 1981	Customer Name	% Use of Total MWh Deliveries
Minnesota			
Anoka	127,167	Federal Cartridge	15
		Cornelius Company	8
		Thermo Serve	5
Arlington	10,290	Big Stone, Inc.	8
Buffalo	29,571	Buffalo Memorial Hospital	5
Chaska	55,896	Preferred Products	5
		School District 112	5
Delano	15,032	Granite Works	10
		School District 879	7
Elk River	40,764	Roma Tool	5
		School District 728	8
Glencoe	42,502	Green Giant Company	22
		Glencoe Bretline Products	8
Kenyon	9,242	Folderaft Company	15
LeSueur	35,750	LeSueur Foundry	22
		LeSueur Creamery	15
		Green Giant Company	11
New Prague	40,013	International Multifoods	46
		Minnesota Valley Engineering	9
		A.M.P.I.	6
North St. Paul	49,000	Berwald Invest.	9
		Target	5
Princeton	24,213	Plastic Products	7
		Smith Systems	7
		School District 477	7
Shakopee	64,038	Toro Manufacturing	6
		K-Mart	5
Wisconsin			
Centuria	DNA		
New Richmond	DNA	DoBoy Industries	5
River Falls	DNA	Univ. of Wisconsin, River Falls	25

Source: Minnesota Department of Energy and Economic Development, 1981.

STATEMENTS OF PROBLEMS, NEEDS, AND OPPORTUNITIES IN THE STUDY AREA

The Nation's long-term problem of expanding energy consumption in the face of a complex and expensive fossil fuel supply has been documented in many recent studies. The expected demand for electrical energy in Minnesota and Wisconsin requires continued and likely increased planning for use of nonrenewable fuels. The combined capacity of seven proposed projects in the St. Paul District and the proposed projects in the Rock Island District probably is not sufficiently large to affect regional planning for future electrical generation using fossil fuels. However, development of these hydropower sites presents an opportunity to develop a dependable, safe, environmentally sound, and relatively inexpensive source of electricity.

The savings in costs of power production would be realized by literally thousands of households. The 7.2 MW project proposed at locks and dam 1 would serve 3,575 homes and save about 36,500 barrels of oil annually. This project is an opportunity to contribute to solving the continuing problem of the United States' increasing need for inexpensive energy.

PLANNING CONSTRAINTS

Any possible added hydropower development plan proposed for locks and dam 1 must be technically and economically sound, socially and environmentally acceptable, and capable of being implemented. Technical factors include constraints that:

1. The plan must fit in with the geometric configuration of the existing structure and not adversely affect navigation, which is the principal and primary purpose for locks and dam 1.

2. The plan must operate in conjunction with or improve efficiency of the existing hydropower plant.

3. The plan must operate as a run-of-the-river facility with minor ponding, defined so as to stay within navigation related restrictions of the existing FERC license number 362 and to minimize adverse environmental and social effects.

4. Raises of the dam or flashboard system to increase head or ponding will not be considered because of tremendous construction cost, interruption of navigation and the existing power plant, and the potential for significant environmental impacts.

5. Hydroelectric turbines and generators to be evaluated will primarily be proven designs that are currently available from manufacturers. This availability generally reduces the engineering design cost of these facilities, and the power output is considered to be more predictable and dependable.

6. The addition of hydroelectric generating facilities cannot significantly inhibit conveyance of flood flows. The facilities should also be accessible during flooding because sufficient head would be available for continued generation during all but the major floods.

7. The addition of hydroelectric generation facilities cannot result in changes that would significantly affect flow regulation, water storage, or normal fluctuations of water surface elevations. The existing water control plan cannot be significantly modified.

8. Water resource projects planned by the Corps of Engineers must have anticipated economic, environmental, and social benefits that exceed the combined expected costs of the project.

9. The project must be constructed, operated, and maintained within the authority given by Congress.

10. This project will be constrained by all the laws of the United States and the State of Minnesota, all Executive Orders of the President, all engineering regulations of the Corps of Engineers, and by sound engineering practices.

11. Additions to and modifications to the site that temporarily interfere with existing power production will have the estimated project benefits reduced by an amount equal to the lost generation.

Possible adverse impacts on wild and scenic rivers, historic sites, endangered species, migratory fish, wildlife, and other environmental amenities must be assessed. Significant impacts should be avoided if possible and mitigated when they cannot be avoided.

Finally, the authority for this study limits the area of consideration solely to that of the original and existing project. Any other options not directly associated with locks and dam 1 would have to be addressed under other authorities.

SPECIFIC PLANNING OBJECTIVES WITHIN STUDY AREA

The objectives of the study are derived from problems and concerns identified for the area and from Federal, State, and local coordination. In addition, the "Principles and Guidelines for Planning Water and Related Land Resources" require that all federally-assisted water resource projects be planned to achieve the national objectives stated earlier.

Specific planning objectives are definite needs, opportunities, and problems that can be addressed to enhance national economic development or environmental quality. Specific planning objectives for this study include:

1. Increase the national economic efficiency through the development and full utilization of a renewable and less costly energy source, thus helping to reduce dependence on foreign fuels in the Nation and study area during the period of analysis.

2. Contribute to a maximum reduction in the use of nonrenewable fossil fuels in the study area and the Nation during the period of analysis, resulting in conservation of those resources and in the enhancement of the environment by reducing air pollution associated with plant emissions and terrestrial degradation associated with fossil fuel discovery and mining.

3. Minimize site-specific environmental effects of added hydropower development (particularly, those effects dealing with barriers to fish migration and entrainment or impingement of aquatic biota).

4. Preserve the historic and aesthetic quality of the existing project site and the adjacent Minnehaha Falls Park Historic District and Minnesota Soldiers Home during the period of analysis.

5. Preserve the existing recreational and fisheries values associated with the island area just downstream of the dam during the period of analysis.

PLAN FORMULATION

PLAN FORMULATION RATIONALE

The purpose of formulating a number of preliminary plans is to ensure that the national and specific planning objectives are met in the best possible method. The preliminary alternatives must be sufficiently varied and numerous so that the best and most feasible solution can be selected. Recent U.S. Water Resources Council guidance states that the economic optimum plan will be selected unless there is good reason to select another plan, such as a significant environmental value. For hydropower projects, economic optimum means the greatest amount of power generation for the lowest possible cost (maximum net benefit). At a given alternative site, this rule guides turbine and equipment design and selection.

Plan formulation for this project was highly constrained by the existing physical conditions. The dependable flow of the river limited the ultimate installed capacity of the projects considered. A detailed list of the planning constraints is in a previous section of this report.

An interdisciplinary team was assembled in the earlier reconnaissance study to develop a strategy for selecting sites in the vicinity of locks and dam 1. With the team approach, various hydropower sites could be considered in terms of the national and specific objectives by expert professionals representing the pertinent disciplines. During the reconnaissance effort, the study team formulated multiple levels of generation capacity at two sites using standardized tube-turbine packages. In the feasibility study, the Corps of Engineers Hydroelectric Design Center at Portland, Oregon, became involved because of the greater level of detail necessary. The design center

considered other types of turbine units and additional sites. That study of additional units and other sites produced greater confidence in what the economic optimum might be.

LOCATIONS CONSIDERED

The following four plans have been studied in detail because they are the most feasible alternatives. The appendix contains several plates showing these designs and descriptions of the technical details of the turbines in these alternatives.

Plan A

This site would require a large surface excavation at the left abutment between the existing power plant and the east bluffline. The powerhouse would be underground with a concrete-lined intake and tailrace. Several combinations of number, size, and models of turbine units were considered at this site to identify the economic optimum.

Plan B

The powerhouse for this plan is also underground at the left abutment, with a concrete-lined penstock and tailrace. The construction would be accomplished by tunneling through the existing bedrock system and then lining the tunnel to protect the erodable bedrock. The tunnel would be located at the base of the east bluff. Several turbine configurations were evaluated.

Plan C

This powerhouse would be on the downstream apron of the existing Ambursen dam. The existing dam is constructed so that it could be partially disassembled in a section wide enough to construct an intake forebay area. The powerhouse could be constructed anywhere along the

dam, but was located approximately 70 feet from the existing powerhouse for several reasons. One reason for selecting this location along the dam is that it provides sufficient room between the existing and proposed powerhouses for the use of the sheet-pile cofferdam required for the new construction. The proposed location also allows the continued use of the three operational sluiceways through the dam. The Ford Motor Company presently uses these three sluiceways in conjunction with the operation of the existing turbines to control the pool elevation, as directed by the St. Paul District Engineer. The final consideration for the powerhouse location is to provide the shortest electrical connection between the proposed generator and the existing power grid located within the existing powerhouse.

Several turbine configurations were considered that led to the selection of a tube turbine unit. Plan C with a tube turbine requires only shallow excavation work. Bulb turbines at this location require such a deep excavation that a separate plan was designated for essentially the same location. The bulb turbine version was called plan "D".

Plan D

This powerhouse would be on the downstream apron of the existing Ambursen dam. The dam would be removed in a section wide enough to facilitate installation of the powerhouse. This plan varies from plan C in that a bulb turbine would be used. The bulb turbine requires a very deep excavation and a grout system to stabilize the adjacent dam buttresses.

The other plans listed below were also considered, but not in the same detail as the preceding plans.

Riverward Lock

This lock chamber was considered on a very preliminary basis.

Right (West) Abutment

The right abutment area is where the existing Federal navigation locks and attendant facilities are located. Preliminary consideration was given to locating the powerhouse either at ground level or below the surface and between the bluff and existing Corps buildings. This might be similar in concept to either plan A or B, as described above but on the west bank.

Existing Powerhouse

The existing equipment is 60 years old. The switching equipment is outdated and probably should be replaced. The turbines are worn and are believed to be wasting water. The powerhouse building is in excellent condition. The best alternative using the existing powerhouse would involve rebuilding the turbines and generators and installing modern switching equipment.

SITE DESIGNATION BY NORTH PACIFIC DIVISION (NPD)

The St. Paul District has designated the alternative project locations as described in the previous report section. NPD designated plans C and D differently; plan C is adjacent to the existing powerhouse and plan D is 70 feet away from the existing powerhouse. NPD recommended plan D with tube turbines. The District's designation is plan C for the tentatively recommended plan, which is equivalent to NPD's designation of plan D.

MANAGEMENT MEASURES

Nonstructural Alternatives

Nonstructural hydropower measures generally relate to energy conservation measures to decrease demand, level peak loads, and change pricing policy. The National Energy Act of 1979 requires all utility systems to use electricity conservation in a broad spectrum of applications intended to reduce the rate of growth of consumption, to the extent economically feasible. It is assumed that conservation features will continue to be required of all utilities, including the so-called Federal-preference utilities. One of the preference utilities would likely be the ultimate non-Federal sponsor for a Federal hydropower project and thus would automatically incorporate the required nonstructural measures into a Federal project. Additionally, the Water Resources Council NED benefit manual exempts all 25-megawatt or smaller hydropower proposals from having to identify a primarily nonstructural alternative. The scale of development proposed for locks and dam 1 qualifies for that exclusion.

Structural Alternatives

Only the 3-meter tubular turbine was considered during the previous 1981 reconnaissance study. The Corps Hydroelectricpower Design Center at Portland, Oregon, was involved in additional turbine selection efforts during this feasibility study.

Various sizes and numbers of bulb and tube turbines and four power plant locations were considered beyond the preliminary stage in this feasibility study. Plates 6 and 7 shows the locations of the four plant sites considered (plans A, B, C, and D).

3.8-Meter Tube Turbine. - This alternative turbine configuration is a standardized design bulb-type Kaplan turbine with a runner diameter of

3,800 mm (millimeters). This turbine was considered for plans A, B, and C (see plates 6 and 7).

3.6-Meter Tube Turbine. - This alternative turbine configuration is a standardized design tube-type Kaplan turbine made by Allis-Chalmers. It has a runner diameter of 3,600 mm. This turbine was considered for plan C, shown on plate 6.

3.0-Meter Tube Turbine. - This alternative turbine configuration is a standardized design tube-type Kaplan turbine with a runner diameter of 3,000 mm. This turbine was considered for plan C, as shown on plate 6.

Water Control Changes - Fluctuation of Pool Levels

The existing hydropower plant operates only in the run-of-the-river mode. Only run-of-the-river alternatives were investigated at locks and dam 1. Run-of-the-river indicates that the turbine operating plan utilizes river flows as they arrive at and pass through the dam. This type of operation does not produce as much energy during peak demand times of the day as a turbine operation plan called "peaking." Peaking consists of storing water at the dam during hours when customer demands for electricity are low, and then releasing the water to generate larger amounts of electricity during hours when customer demands for electricity are greatest. However, the larger fluctuations of water surface levels that are associated with peaking are unacceptable for a number of reasons.

NO ADDITIONAL FEDERAL ACTION ALTERNATIVE

No Federal Action, No Change From Existing Conditions

If no federally-added hydropower is developed, it is possible that no change from the existing conditions would occur at the locks and dam 1 site. This scenario would have no additional environmental or social

impacts, other than those expected under present conditions. However, if the feasible hydropower potential is not developed at this site, several opportunities would be lost. These opportunities include full utilization of a renewable and environmentally clean energy source and capitalization of a relatively economical source of energy. There would be some economic and environmental costs or losses involved with fossil fuel generation that would be used to take the place of the undeveloped hydropower generation.

No Federal Action, Non-Federal Hydropower Development

There is another possible scenario if no additional Federal action is taken. Some non-Federal group could develop the feasible hydropower potential at locks and dam 1. The Ford Motor Company operates the existing power plant and might seem to be the most likely non-Federal developer. In fact, the Federal Energy Regulatory Commission (FERC) could, under certain conditions, require the Ford Company to install the additional capacity or make other changes in the project to the extent that is economically sound and in the public interest. However, FERC has indicated that some other qualified non-Federal developer could also develop the additional potential at locks and dam 1. Northern States Power (NSP) is presently operating hydropower plants at Upper and Lower St. Anthony Falls, about 5 miles upstream from locks and dam 1. NSP may consider developing this site.

Impacts of non-Federal redevelopment or other hydropower addition would probably not differ appreciably from those that would occur with Federal development. Opportunities foregone in the no Federal action alternative would be regained with responsible non-Federal development. Responsible development is insured to some level by the FERC licensing process. As part of the licensing process, FERC would request the Corps of Engineers to review the license to determine whether any non-Federal proposals would be compatible with the existing navigation project and related project purposes.

PLANS OF OTHERS

The Ford Motor Company has been considering a proposal by the General Electric Company to upgrade the existing turbines and generators. This existing equipment is 50 years old and wastes water. Also, improved technology, such as better insulating materials for the generators, would help produce more power from the same volume of copper windings. The Ford Motor Company will make an independent decision concerning whether they wish to upgrade their equipment. If the upgrade takes place, minor adjustments in flow and power calculations may be needed for the Federal analysis in any possible future work.

If the Ford Motor Company upgraded their equipment as proposed by the General Electric Company, then their hydropower plant would use less water. Thus, an additional increment-of-energy benefit would accrue to strengthen the feasibility of the Federal project. The dependable capacity of the proposed Federal project would probably also increase somewhat. However, this scenario probably would not justify a larger capacity installation by the Federal Government. Although Ford Motor Company is not presently considering such action, it could attempt to install larger turbines. If Ford received the required license to do that, the Federal project would likely be precluded.

PROJECT OPERATION ASSUMPTIONS FOR FEDERAL EVALUATION

A key assumption in these studies was that the existing units will receive "first water." Thus, any new generating units will operate on river flows in <u>excess</u> of the hydraulic capacity of the existing hydropower plant. This assumption was made because the FERC license for the existing hydropower plant guarantees the right of first water until the year 2003.

The "first water" operation plan is a distinct disadvantage for adding new hydropower units to this site. The frequency of flows in excess of the existing plant's capacity is much less than the frequency of flows available to the existing turbines. This would mean the new turbines would generate electricity less often than the existing turbines. In spite of this disadvantage, however, the addition of a new hydropower plant appears economically feasible. Moreover, there are alternative operating plans that could improve the economic feasibility of a new plant while maintaining the benefits of the existing plant. However, those operating plans are too complicated to analyze for the level of detail of this study.

If more detailed engineering and design studies are done, the "first water" assumption should be examined more closely. The operation of a new hydropower plant could be better coordinated with the operation of the existing plant. The operation rule of "first water" does not automatically maximize electrical generation. The existing equipment is older and less efficient than the new equipment would be. Therefore, the new equipment could produce more electricity, with the same amount of flow.

An electricity transfer could be made to replace the energy that Ford Motor Company woild normally obtain from a given flow. The remaining electricity would go to the sponsor of the new project. Such a contractual arrangement would make the new hydropower project more economically attractive. According to hydropower experts at Nortn Pacific Division of the Corps, this type of arrangement has been successfully implemented at other sites.

COMPARATIVE REVIEW OF PRELIMINARY ALTERNATIVES

Plan A - Underground Powerhouse (Open Excavation)

Advantages:

1. Increased capacity.
2. Proximity to existing power grid.
3. Concentrates all generation capability at the site.
4. Uses existing trash boom system.
5. Access good.
6. Powerhouse hidden; aesthetics retained.
7. Adjustable blades and wicket gates enhance operation flexibility.

Disadvantages:

1. Shut down two of four existing turbines for 18 months.
2. Excavation highly disruptive to existing plant.
3. Difficult excavation; 40-foot vertical walls.

Plan B - Underground Powerhouse (Tunnel Excavation)

Advantages:

1. Increased capacity.
2. Proximity to existing power grid.
3. Concentrates all generation capability.
4. Uses existing trash boom system.
5. Access good.
6. Powerhouse hidden; aesthetics retained.
7. Adjustable blades and wicket gates enhance operation flexibility.

Disadvantages:

1. Construction moderately disruptive to existing plant.
2. Tunneled excavation is moderately difficult.

Plan C - Powerhouse on Dam Apron

Advantages:

1. Adjustable blades and wicket gates enhance the flexibility of operation.
2. Increased capacity.
3. Located entirely on Federal right-of-way.

Disadvantages:

1. Moderate decrease in flood conveyance capacity for larger floods.
2. Powerhouse may be aesthetically distracting.
3. Access potentially difficult, especially during floods.
4. Potential structural stability problems with existing dam during construction.
5. Minor inconvenience to existing plant.

Plan D - Powerhouse on Dam Apron

Advantages:

1. Adjustable blades and wicket gates enhance the flexibility of the existing operation.
2. Increased capacity.
3. Located entirely on Federal right-of-way.

Disadvantages:

1. Slight decrease in flood conveyance capacity for larger floods.
2. Powerhouse may be aesthetically distracting, but less visible than plan C.
3. Access potentially difficult, especially during floods.
4. Potential structural stability problems for Ambursen dam during powerhouse construction.
5. Minor inconvenience during construction to existing powerplant.

Riverward Lock

Advantages:

1. Increased electrical generation capacity beyond existing conditions.
2. Operation more easily accomplished with existing lock personnel because of proximity to existing navigation project.

Disadvantages:

1. Interference with navigation by concentrating river flows through the turbine and directing additional current into the navigation channel.
2. Precludes use of lock for navigation.
3. Probably would decrease flood-flow conveyance; the lock chamber could be used to pass flood flows in an emergency.
4. Long grid connection through hollow dam; more costly to construct and maintain; additional safety concern.

Upgrade of the Four Existing Turbines (Ford Motor Company)

Advantages:

1. Increased capacity of existing units.
2. Option can be accomplished independently of the other plans being considered without precluding them.
3. Non-Federal implementation is most appropriate.
4. Increase flows available for all other alternatives.

Disadvantages:

1. Disruption of service during replacement.

Right (West) Abutment

Advantages:

1. Increased electrical generation capacity beyond the existing conditions.
2. Operation more easily accomplished with existing lock personnel because of proximity to existing navigation project.

Disadvantages:

1. Interference with navigation by concentrating river flows through the turbine and directing additional current into the navigation channel.
2. Significant disruption of existing lock operations during 2-year construction period.
3. Construction of cofferdam might interfere with barge traffic.
4. Long grid connection through hollow dam; more costly to construct and maintain; additional safety concern.

PRELIMINARY SCREENING OF ALTERNATIVES

The St. Paul District's reconnaissance report (September 1981) formed the basis for preliminary economic evaluation. The following summary table is from that report. Annual costs and benefits are displayed for 4.0 and 8.0 MW development at sites B and C. Note that the costs in this table are based on tube turbine units at December 1980 prices and a 7-3/8-percent discount rate rather than the October 1983 prices and 8-1/8-percent rate used in this report. The project life for economic evaluation is 100 years, with a project rehabilitation assumed to occur at project year 50. Project benefits were derived from power values provided by the Federal Energy Regulatory Commission (FERC).

Summary Table From September 1981 Reconnaissance Report
Average Annual Costs and Benefits (1)

Item	Amount ($1,000's) Plan C 4,000 kW	Plan C 8,000 kW	Plan B 4,000 kW	Plan B 8,000 kW
First costs	4,700.0	8,290.0	5,760.0	10,000.0
Present worth of deferred costs (2)	23.0	31.0	23.0	31.0
Interest during construction (3)	327.0	576.8	401.0	695.7
Present worth of salvage value (4)	(6.0)	(9.0)	(6.0)	(9.0)
Net Federal investment	5,044.0	8,888.8	6,178.0	10,717.7
Average annual charges	372.3	656.1	456.0	791.1
Operation and maintenance	22.0	39.0	27.0	47.0
Average annual costs	394.3	695.1	483.0	838.1
Average annual energy benefits (5)	378.3	725.1	378.3	725.1
Average annual capacity benefits(6)	16.0.	303.2	160.0	303.2
Total average annual benefits	538.3	1,028.3	538.3	1,028.3
Net benefits	144.0	333.2	55.3	190.2
Benefit-cost ratio	1.37	1.48	1.11	1.23

(1) 7-3/8-percent interest rate, December 1980 prices.
(2) Deferred costs are the present worth of the value of costs required for project rehabilitation at year 50.
(3) Considers 2-year construction period.
(4) Considers present worth of the value of salvageable machinery at year 50 and year 100.
(5) Average annual energy benefits are equal to FERC escalated energy value multiplied by the additional generation with the alternative.
(6) Average annual capacity benefits are equal to FERC capacity benefit value multiplied by the additional capacity with the alternative.

The reconnaissance study indicated that a variety of alternative plans might generate more annual benefits than costs. With the limited information available at that time, the best plan appeared to be plan C, two tube turbines (8 MW), on the dam apron. The reconnaissance investigation also indicated that the additional hydropower development at locks and dam 1 would not cause significant environmental impact.

CONCLUSIONS OF THE PRELIMINARY COMPARATIVE REVIEW

The District study team accomplished a preliminary comparative review shortly after initiation of the feasibility study. The review led to the following two conclusions:

1. The North Pacific Division (NPD) Hydroelectric Design Center should be involved in the detailed feasibility level studies for this site.

2. Only plans A, B, C, and D should be evaluated by NPD. The other locations either interfere with the existing navigation project or would be better implemented by the existing hydropower operator, Ford Motor Company.

Plans B and C were conceptualized during the District's reconnaissance report. Plan A was conceptualized later, during a field visit by NPD on November 4, 1982. Plan D was conceptualized as a result of a late stage iteration of powerhouse design work for plan C.

The four plans are described, beginning on page 41. Plates 6 and 7 show plan views of the four alternatives.

ASSESSMENT AND EVALUATION

FEASIBILITY REPORT EVALUATION

Evaluation of Turbines

North Pacific Division (NPD) began active involvement in this feasibility study with their inspection of the locks and dam 1 site on November 4, 1982. Plans A, B, and C were selected by the St. Paul District for detailed evaluation by NPD. The NPD evaluation included the following:

1. Review the hydrologic availability.
2. Obtain and analyze current power values from FERC.
3. Estimate powerhouse costs based on recent construction and incorporate civil costs provided by the District.

First, NPD estimated the level of installed capacity that should optimize the economic performance. This was done by estimating the theoretical energy available from flows passing over the dam without regard to a particular alternative site. This effort, called project scoping, is summarized on the following table. The table was taken from the initial draft technical report received from NPD in May 1983. The technical report was subsequently modified and resubmitted to the St. Paul District in May 1984. Note that the entire range of installed capacity from 7.8 MW to 24.5 MW was nearly feasible. Detailed design efforts began with the 13.5 MW installed capacity because of the slightly greater net benefits at that capacity. However, the installed capacity varied widely during various stages of plan formulation. This occurred because the type and number of turbines selected proved to be sensitive to small variations in economic assumptions for both the annual costs and annual benefits.

Later, NPD modified the scoping table, specifically considering tube turbines. The information is shown on table 6-4 of the technical report contained in this feasibility report as an appendix. For a more detailed description of project scoping work, see section 6.07 of the appendix (Technical Report).

Summary of the Initial Project Scoping Effort
(October 1982 Price Levels, $1,000's)

	Installed Capacity				
	1.3 MW	7.8 MW	13.5 MW	19.3 MW	24.5 MW
Generation					
Dep. Capacity MW (1)	0.6	2.7	3.8	4.6	5.2
Annual Energy Mwh	4,600	21,700	32,200	40,000	45,600
Plant Factor (2)	40%	32%	27%	24%	21%
Costs					
Annual Cost (3)	870	1,400	1,868	2,330	2,730
Production Cost (4) (mills/kwh)	189	65	58	58	60
Benefits					
Annual Capacity (5)	106	478	673	814	920
Annual Energy (6)	173	825	1,224	1,520	1,734
Total Annual (7)	279	1,303	1,897	2,334	2,654
Net Benefits (8)	-591	-97	29	4	-76
Benefit-Cost Ratio(9)	0.32	0.93	1.02	1.00	0.97

(1) From the initial draft of the NPD Technical Turbine Report dated May 1983.
(2) (Annual Energy, MWh)/(Installed capacity, MW x 8760 hours).
(3) Annual Cost for selected plant from the initial draft of the NPD Technical Turbine Report dated May 1983.
(4) (Annual Cost, $)/(Annual Energy, kWh x 1000 mills/$)
(5) (Dependable Capacity) x $177.000/kW-yr.
(6) (Annual Energy) x $.038/kWh.
(7) (Annual Capacity Benefit) + (Annual Energy Benefit).
(8) (Annual Benefit) - (Annual Cost).
(9) (Annual Benefit)/(Annual Cost).

First Iteration of Design Work

The table on the following page is taken from the May 1983 initial draft technical report from North Pacific Division (NPD). The table indicates that all three sites, A, B, and C were initially feasible with the 13.5 MW installed capacity. However, the projects were all so marginal that it was expected that a slight decrease in the power values would make all three projects infeasible. Therefore, the St. Paul District requested that the NPD Hydroelectric Design Center do another design iteration at a greater level of detail. The 1983 power values did in fact reduce the benefit-cost ratios to below unity for all three plans as originally designed.

Later Iteration of Design Work

The District selected plan C for more detailed evaluation in the later iteration. Plan C had the best net benefit in the first iteration, and there were indications that the powerhouse location could be adjusted to better fit the site and reduce the civil costs.

The NPD Hydroelectric Design Center also evaluated one large bulb turbine in place of the two smaller tube turbines for plan C. The single bulb turbine version required a quite different powerhouse. For that reason, the bulb turbine version of plan C was dubbed plan D, even though the two plans were designed for the same location. The excavation required for plan D (bulb) is significantly deeper than that required for plan C (tube). The additional excavation and related stabilization cost for the plan D bulb turbine eliminated the plan from further consideration. Economic and physical data for the final array of detailed alternatives (A, B, and C) are shown on the tables in following sections of the report.

Economic Summary, Alternate Powerhouse Locations
(For Selected Plant Size 13.5 MW, $1,000's, October 1982 Prices)

	Alternative A Left Abutment Open Excavated Powerhouse	Alternative B Left Abutment Tunneled Powerhouse	Alternative C Right Side
Physical Data			
Plant Size	13.5 MW	13.5 MW	13.5 MW
Number of Units	1	1	1
Type of Units	bulb	bulb	bulb
Cost			
Powerplant Equipment	5,485	5,380	5,720
Items Exclusive	7,446	9,310	6,812
Loss of Existing Power	1,546	0	1,546
Construction Cost	14,477	14,690	14,078
Contingencies	2,630	2,699	2,558
Subtotal	17,107	17,359	16,636
Inflation Adjustment	- 822	-1,028	- 752
Subtotal	16,285	16,331	15,884
ED S, and A	1,954	1,960	1,906
Subtotal	18,239	18,291	17,790
IDC	3,188	3,197	3,109
Investment Cost	21,427	21,488	20,899
I&A	1,688	1,693	1,646
O&M	74	74	74
R	101	101	101
Total Annual Cost	1,863	1,868	1,821
Total Annual Benefit	1,897	1,897	1,897
Net Benefit	34	29	76
Benefit-Cost Ratio	1.02	1.02	1.04

REAL ESTATE REQUIREMENTS

Existing Project

The property boundaries for the existing Ford hydropower project are shown on plate 5. The information source for this plate is exhibit K of FERC license number 362 granted to the Ford Motor Company (December 30, 1948). Plate 5 indicates the areas that are Federally-owned and those that are owned by Ford Motor Company.

Plan A

This plant, including the head and tailraces, would be constructed entirely on Federal property. The project would not affect the elevation of either pool 1 or 2. Plate 8 shows that plan A would not affect the crest rating curve because the plant would be underground and would not reduce the effective flood conveyance capacity of the site. Thus, no additional flowage easements would be required. Most of the heavy construction equipment and turbine parts would probably need to be brought in by barge. Access to and from the site for light equipment or materials and construction workers would be by the existing access road. A temporary easement for a 1-acre work site is estimated to cost $10,000. The temporary use of an existing disposal area for disposal of excavated material is estimated to cost $10,000.

Plan B

This plant and its appurtenances would also be constructed entirely on Federally-owned property. The plan B hydropower plant would operate exactly the same as plan A. Thus, no additional flowage easements would be required. Construction of plan B would require the same rights of way as plan A. Interference with the operation of the existing plant would have to be minimized. Access would have to be provided through the Federal construction site to allow continued

operation of the existing Ford hydropower plant. Construction easements are estimated to cost $10,000 and the temporary use of an existing disposal area is estimated to cost $10,000.

Plan C

This plant and its appurtenances would be constructed entirely on Federal property. The plant would be operated so that no additional flowage easements would be required. However, the presence of the powerhouse on the dam apron would modify the crest rating curve, as indicated on plate 8. The elevation of pool 1 would be raised, up to as much as 1 foot, during major flooding events. The elevation of pool 2 would not be affected by the presence or operation of plan C. The St. Paul Real Estate Office has determined that the elevation increase in pool 1 during major floods would fall within the project boundaries for the existing Federal navigation project. Thus, no additional flowage easements would be required. Most of the heavy construction equipment and turbine parts would probably need to be brought in by barge. Ingress and egress of light equipment or materials and construction workers would be by the access road provided as part of the existing project number 362, as shown on plate 5. A temporary easement for a 1-acre construction work site is estimated to cost $10,000. Temporary use of an existing disposal area for excavated material is estimated to cost $10,000.

Plan D

This plant and its appurtenances would be constructed entirely on Federal property. The plant would be operated so that no additional flowage easements would be required. However, the presence of the powerhouse on the dam apron would modify the crest rating curve, as indicated on plate 8. The St. Paul Real Estate Office of the Corps has determined that the pool 1 raise during major floods falls within the project boundaries of the existing Federal navigation project. Thus,

no additional flowage easements would be required. The construction rights of way requirements for plan D are essentially the same as for plan C. A temporary construction easement for a 1-acre site is estimated to cost $10,000. Temporary use of an existing disposal area for excavated material is estimated to cost $10,000.

COMPARISON OF DETAILED PLANS

Contributions of Plans to the National Objective

The following table displays the effects of plans A, B, and C on the national objective of maximizing net benefits. Net benefits are defined as project benefits minus project costs.

Alternative Effects on National Objectives

Objective	No Federal Action	Plan A	Plan B	Plan C
Net economic benefits	Forgone opportunity	-$44,000	-$53,000	$116,000

Displays Comparing Alternatives

The table on the following page compares the effects of four alternatives (plans A, B, C, and D) and the no action plan on the planning objectives. Generally, all four alternatives would benefit the public at the cost of minor inconvenience during construction. The table provides more specific information for each alternative.

Alternative Effects on Planning Objectives

Planning Objectives	No Federal Action	Located on Bluff		Located on Dam Apron	
		Plan A	Plan B	Plan C	Plan D
1. Widespread public benefit from reduced electrical costs.	No	Yes	Yes	Yes	Yes
2a. Conserve Nation's non-renewable energy resources.	No	Yes	Yes	Yes	Yes
2b. Enhance air quality by reduction of fossil fuel combustion.	No	Small increment	Small increment	Small increment	Small increment
3. Minimize site specific environmental effects.	Yes	Yes	Yes	Yes	Yes
4. Preserve aesthetic quality of existing project area, such as view from new L/D 1 viewing facilities.	Yes	Yes	Yes	Some visitors may consider plan a slight distraction.	Slightly less distraction than plan C but more than the others.
5a. Preserve existing recreational values associated with tailwater island.	Yes	Yes	Yes	Yes	Yes
5b. Preserve existing fisheries values of area surrounding tailwater island.	Yes	Yes	Yes	Yes	Yes

The following table compares the levels of development in terms of the proposed capacities for each alternative.

Comparison of Proposed Capacities

Alternative Plan	Number and Type of New Units[1]	Size of Individual Units (MW)	Net Increased Capacity (MW)	Total Investment Cost[2]
A - Underground	1 bulb	16.0	16.0	$23,412,000
East Bluff	1 tube	7.2	7.2	13,567,000
B - Tunnel East	1 bulb	16.0	16.0	24,087,000
Bluff	1 tube	7.2	7.2	13,685,000
C - Dam Apron	1 tube	7.2	7.2	11,607,000
C - Dam Apron	3 tube	16.0	16.0	23,734,000

(1) Other turbine sizes and combinations were considered on a preliminary basis. See table 3-2 of the NPD Technical Report, included as an appendix to this feasibility report.
(2) 1983 price levels from table 6-5 of the appendix (NPD Technical Report).

The table on the following page presents the system of accounts information, required by the National Environment Policy Act of 1969. The four accounts also encompass social well-being as required by Section 122 of the Flood Control Act of 1970 (Public Law 91-611, 84 Statute 1823). The four applicable accounts are:

- o National Economic Development (NED)
- o Environmental Quality (EQ)
- o Regional Economic Development (RED)
- o Other Social Effects (OSE)

The NED account shows project effects on the national economy. The RED account shows the regional incidence of NED effects, income transfers, and employment effects. The OSE account shows urban and community impacts and effects on life, health, and safety. The EQ account shows effects on ecological, cultural, and aesthetic attributes of significant natural and cultural resources.

System of Accounts - Alternative Plans for Added Power[1]

Account	No Federal action	Plan A 1 Tube Turbine	Plan B 1 Tube Turbine	Plan C 1 Tube Turbin-
National Economic Development				
Annual NED benefits	0	$1,151,000	$1,151,000	$1,151,000
Annual NED costs	0	1,195,000	1,204,000	1,035,000
Net NED benefits	0	-44,000	-53,000	116,000
Benefit-to-cost ratio	0	0.96	0.96	1.11
Installed capacity (MW)	0	7.2	7.2	7.2
AAE (MWh)	0	21,450	21,450	21,450
Plant factor %	0	34	34	34
Environmental Quality				
Air quality	No change	Temporary disturbance during construction; reduced use of fossil fuel.	Same as plan A.	Same as plan A.
Water quality	No change	Minor effects on turbidity during construction.	Same as plan A.	Same as plan A.
Aquatic resources	No change	No adverse impact	No adverse impact	No adverse impact
Endangered species	No change	No impact	No impact	No impact
Archeological and historic resources	No change	No impact	No impact	No adverse impact
Recreational resources	No change	No impact	No impact	No impact
Regional Economic Development				
Desirable community growth	No change	No impact	No impact	No impact
Local government finance				
Tax revenues	No change	No impact	No impact	No impact
Property values	No change	No impact	No impact	No impact
Other Social Effects				
Displacement of people	No change	None	None	None
Community cohesion	No change	No change	No change	No change
Public facilities	No change	Beneficial	Beneficial	Beneficial
Public services	No change	Beneficial	Beneficial	Beneficial
Average households served[2]	No change	3,575	3,575	3,575
Barrels of oil saved annually[3]	0	36,465	36,465	36,465

(1) 100-year project life, 8-1/8 percent interest, and October 1983 prices.
(2) An average household may use 6 MWh per year of electricity.
(3) 1 7 barrels saved per MWh.

The following table summarizes the annualized benefits and costs, as required by the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, dated March 10, 1983. The table compares the NED benefits and costs for the four alternatives. The plan with the greatest amount of net benefits is called the NED plan.

Summary of Annualized Benefits and Costs

	Alternative		
	Plan A	Plan B	Plan C
Plant Data			
Existing capacity, MW	14.4	14.4	14.4
Installed (proposed) capacity, MW(1)	7.2	7.2	7.2
Dependable capacity, MW (July-August)	2.4	2.4	2.4
Intermittent capacity, MW	4.8	4.8	4.8
Average annual energy, gWh	21.45	21.45	21.45
Average plant factor (%)	34	34	34
Benefits(1)			
Unit capacity value ($/kW-year)	203.31	203.31	203.31
Dependable capacity benefits	488,000	488,000	488,000
Intermittent capacity benefits	None	None	None
Adjusted unit energy value ($/kWh)	.0309	.0309	.0309
Unadjusted energy benefit values	.0189	.0189	.0189
Operating flexibility credit (%)	5	5	5
Mechanical availability	0.985	0.985	0.985
Thermal availability	0.76	0.76	0.76
Total hydro benefits(1)	1,151,000	1,151,000	1,151,000
Annualized Cost(1)	1,195,000	1,204,000	1,035,000
Structural measures	(1,195,000)	(1,204,000)	(1,035,000)
Nonstructural measures	(-0-)	(-0-)	(-0-)
Net annual benefits(1)	-44	-53	116

(1) Does not include existing Ford Motor Company hydropower plant.

The Principles and Guidelines also mention another display that is sometimes necessary if the nature or magnitude of hydropower benefits change substantially over time. Major examples of such changes are listed below:

- o Staged construction of hydropower project.
- o Changed role of hydropower in system.
- o Large projects that take several years to be absorbed into the system.

These three cases are not applicable to the locks and dam 1 hydropower study. Therefore, the display related to benefit changes over time would be meaningless and is not included.

Trade-off Analysis

All hydropower projects require that something of value be invested when the project begins in order to obtain future benefits from the project. If all investments were made in strictly monetary terms, the decision would be much simplified. If project benefits, in dollar terms, exceeded project costs, in dollar terms, then the project would be worthwhile to build. However, the real world is not that simple. Often, with public works projects, valuable resources must be given up (or invested) without a dollar cost figure that can be attached to the resource being sacrificed. A trade-off analysis is intended to provide a consideration of the monetary versus nonmonetary resources involved in this public hydropower project.

The table on page 63 displays the significant resources of the project area versus dollars in the system of accounts format. The national and regional economic development accounts display the dollar benefits and costs. The environmental quality and other social effects accounts display the significant nonmonetary resources of the study area.

In monetary terms, the alternative plans are justified, or nearly so. In nonmonetary terms, the public must put up with the disruption and short-term environmental effects of construction to obtain better public facilities. The use of renewable energy resources would preserve an increment of non-renewable energy resource for possible future use. The additional hydropower project would also have a slight benefit of not polluting the air because it would save an increment of fossil-fuel from being burned.

Summary of Comparative Displays

In summary, these displays are provided to facilitate the evaluation and comparison of alternatives. Such evaluation and comparison is necessary to make the following determinations:

- The effectiveness of given plans in solving the problems and taking advantage of opportunities identified in the planning process.

- What must be given up in monetary and nonmonetary terms to enjoy the benefits of the various alternative plans.

- The differences among alternative plans in terms of their effects as shown in the four accounts.

NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN

The NED plan maximizes net annual economic benefits. Net annual economic benefits are determined by subtracting annual economic costs from the annual economic benefits. For hydropower projects, the NED objective is to maximize energy production in conjunction with minimizing construction, maintenance, and operation costs. Plan C is the NED plan.

THE TENTATIVELY RECOMMENDED PLAN

The new Principles and Guidelines of the Federal Water Resources Council require that the recommended plan be the NED plan, unless the Secretary of a department or head of an independent agency of the Federal Government grants an exception to this rule. Exceptions may be made when there are overriding reasons for recommending other than the NED plan, based on other Federal, State, local, or international concerns. The recommended plan must also minimize or eliminate adverse environmental impacts associated with project construction, resource commitment, and operational characteristics.

Plan C is both the NED plan and the tentatively recommended plan. Plan C consists of a single tube turbine that would be located on the apron of the Ambursen dam. See plate 6 for the location of plan C. Cross-sections and other detailed drawings of the powerhouse are included in the technical report appendix.

Plan C adds 7.2 MW of generating capacity to the existing 14.4 MW site capacity. The powerhouse and intake channel would be constructed through the existing dam, to the west of the existing powerhouse. The photographs on the following two pages include an artist's concept of the powerhouse and access bridge. One 3.6 meter tube turbine with adjustable blades and wicket gates would be housed in the plant. Like the present operating plan, the proposed and existing turbines would continue to be operated "run-of-river" to maintain a steady navigation pool.

Artist's Concept of Tentatively Recommended Plan

(Drawn on July 1983 Photograph)

Artist's Concept of Tentatively Recommended Plan

(Drawn on July 1983 Photograph)

The following table provides a convenient summary of the tentatively recommended turbine and details.

Locks and Dam 1 Tentatively Recommended Plan - Turbine and Related Details

Item	Description
Number of units	1 - (7.2 MW capacity)
Type of turbine	Tube
Shaft	Horizontal
Runner type	Adjustable blade propeller
Number of blades	5
Blade-to-blade clearance	(2)
Runner diameter	3,600 MM
Runner-to-case distance	(2)
Mixed or axial flow	Axial
Wicket gates	Yes; adjustable (2)
Normal gate opening	Full
Maximum discharge	3,050 cfs
Minimum discharge	1,200 cfs
Operational head range	35 to 24 feet
Operation (percent of full capacity - frequency curve)	See annual "flow-duration" curve in technical report by North Pacific Division.
Turbine setting (relative to tailwater)	5.2 feet (1)
Runner RPM	133.33
Mode of operation	Shut down one turbine at a time in conjunction with existing plant.
Trash rack size/spacing	(2)
Monthly hydrographs	See Technical Report from North Pacific Division.

(1) Distance propeller center line is located below minimum tailwater.
(2) Not available until detailed design stage.

CIVIL FEATURES - TENTATIVELY SELECTED PLAN C

Powerhouse

The powerhouse would be located partly on the downstream dam apron and partly on its own foundation downstream of the dam apron. The powerhouse would be constructed of reinforced concrete and would house the control room, mechanical room, and tube turbine. Flow to the turbine would be controlled by the hydraulically adjustable wicket gates. Upstream and downstream closures for maintenance dewatering would be accomplished with permanently installed gates.

Channel and Scour Protection

No intake channel would need to be excavated upstream of the dam. The invert elevation of the concrete intake channel would be roughly equal to the pool bottom elevation. An area of scour protection rock would be placed to protect the sand bottom for a distance upstream of the intake. A permanent trash rack would be installed at the upstream end of the intake channel with a built-in mechanism to clear debris. A tailrace channel will need to be excavated downstream of the powerhouse for a distance of about 200 feet. The tailrace channel will also be protected with riprap rock to prevent erosion of the river bottom from turbine flows.

Access

Personnel access would be by the footbridge. Access to the powerhouse over the footbridge would only be interrupted by rare and extremely large floods. Access for major repair and maintenance would need to be from a barge.

Cofferdams

A sheet-pile cell cofferdam would be installed around the intake area to provide "in the dry" installation of the intake gate structure. The upstream cofferdam would be located so it would not interfere with flows required by the existing powerplant. The downstream cofferdam would also be sheet-pile cell construction with clay embankments across the apron to tie-in to the dam.

The upstream cofferdam would be a single-stage, sheet-pile cell cofferdam. It would require five sheet-pile cells, 33 feet in diameter and filled with sand. The cells would be located to minimize interference with the existing turbines during the construction period.

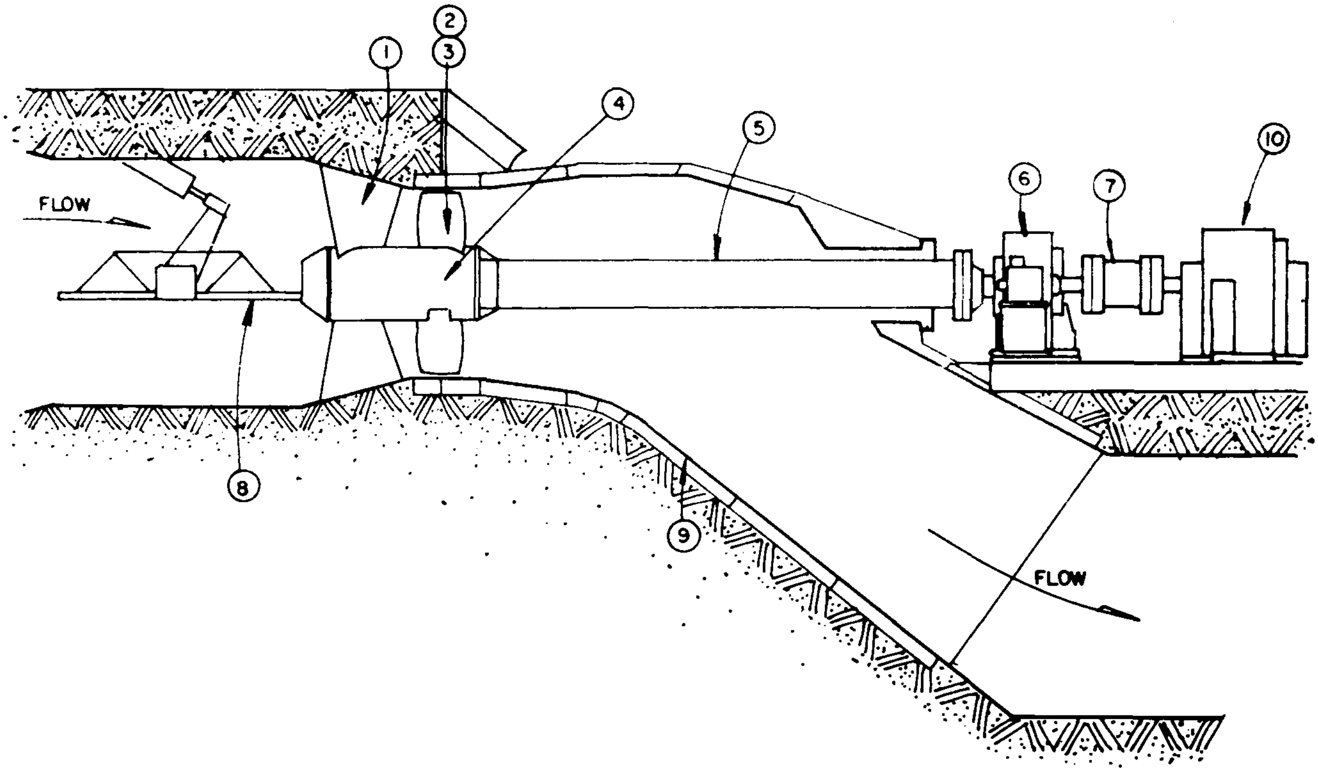
The downstream cofferdam would be a combination of sheet-pile cells and earth embankment. The earth embankment would be needed to cross the dam apron area between the dam and the sheet-pile cells. The four 33-foot diameter cells would be filled with sand. Material for the earth embankment would be a standard clay core.

The top elevation of the upstream and downstream cofferdams would be 4 feet above normal pool elevation to reduce the risk of overtopping during potential flooding of the river. Both cofferdams would be completely removed after completion of the new powerhouse. Dewatering would be accomplished by sump pump.

Turbine

The turbine is a tube design with horizontal shaft and adjustable blades and wicket gates. The following diagram is a cut-away view of a tube turbine and generator. The numbers on the diagram correspond to the definitions of the components they point to.

TUBE TURBINE



1. Guided Vanes - The streamlined stationary components that span the waterway tc provide support for the guide bearing and to provide direction to the water flowing to the runner.

2. Runner - The rotating element of the turbine that converts hydraulic energy into mechanical energy.

3. Runner Blades - The contoured components of a propeller runner that radiate from the hub, deflect the flowing water and transfer the energy to the runner hub. The blades may be angularly adjustable or rigidly fixed in the hub.

4. Runner Hub - The axisymmetric portion of a propeller runner that provides the attachment to the main shaft and that attaches to the inner ends of the runner blades.

5. Main Shaft - The rotating element that transmits torque developed by the turbine runner to the generator rotor or tansmits torque developed by the motor to the pump impeller.

6. Speed Increaser - The geared drive unit that increases turbine shaft speed to drive the generator at an optimum speed for power generation. The speed increaser contains bearings that provide the necessary shaft support and thrust capacity.

7. Flexible Coupling - The shaft connection between the speed increaser and the generator that can accomodate minor misalignment.

8. Inlet Valve - The valve or gate that controls the water flow to the turbine. Wicket gates, as proposed for this application, appear differently than the diagram shows.

9. Draft Tube - The diffuser which regains the residual velocity energy of the water leaving the turbine runner or accelerates the flow as it approaches the pump impeller.

10. Generator - Converts torque from the main shaft to electrical energy by rotating coils of wire through a magnetic field.

Flashboards

The existing flashboard system is operated and maintained by the Ford Motor Company in conjunction with their existing hydropower project. Operation of the flashboard system is specified in FERC license number 362 held by the Ford Motor Company. The flashboards raise the dam crest elevation from 723.1 to 725.1. The flashboards automatically drop when larger flows or ice conditions break the retainer shear pins. Subsequently, Ford employees raise the flashboards and install new shear pins.

With the tentatively recommended plan, the flashboard system would continue to be operated essentially the same as it has been, but with one small modification. During navigation season, the boards have been operated to provide a stable pool. However, the U.S. Fish and Wildlife and Minnesota Department of Natural Resources have expressed concern about the proposed project increasing the chances of having no flow over the dam. If the flashboards are maintained as presently done during low flow conditions, several small pools at the toe of the dam may become stagnant. Plate 6 shows the topography in that area. One possible solution is to lower one flashboard, adjacent to the locks, to allow continued flow through the stagnant pools. This would only be necessary during extreme low flow conditions when all of the flow would otherwise go through the existing and proposed turbines. More detailed analysis is needed to determine the discharge required to freshen those pools under low flow conditions. It is possible that enough leakage already escapes the flashboards to accomplish the flushing action.

During low flow conditions, a small increment of generation would be lost due to the small flow required to freshen the toe pools. The small increment of lost generation benefit would have little effect on the feasibility of the recommended project. The exact amount of lost generation will be identified during the review of the hydrologic power analysis for advanced engineering and design.

SITE DEVELOPMENT OPTIMIZATION

The work by the North Pacific Division Hydroelectric Design Center optimized the development at locks and dam 1. The tentatively recommended plan is therefore the optimum site plan from a Federal perspective. It should be understood that an independent non-Federal developer would be free to use its own design and economic criteria to evaluate the site. Thus, it is possible that a non-Federal project might be at a different installed capacity. It might also be proposed at another location within the locks and dam 1 site.

This evaluation was done at the feasibility study level of detail. If Congress funds more detailed engineering and design work, it is possible that the more detailed information may change the project location to one of the other two sites (A or B) identified in the detailed evaluation portion of this feasibility report.

One of the basic assumptions used in this feasibility study has a major effect on the level of development. In order to make a conservative estimate of project feasibility, the study team assumed that the existing hydropower plant had the right to "first water" up to its hydraulic capacity. During more detailed studies, that assumption might be changed. It is possible to obtain more energy benefit from the same amount of water by assuming a more coordinated operation between the existing and proposed plants. In that case, the proposed capacity may be found to be somewhat greater than the capacity proposed in this feasibility report.

STANDARD PROJECT FLOOD CONSIDERATION

The tentatively recommended plan for the locks and dam 1 site has an effect on standard project flood heights. The proposed plant would be located through the dam and onto the downstream apron of the dam. This location decreases the effective flow area to pass flood flows over the

crest of the dam. Plate 8 shows the effect of the proposed site (plan C) on the existing crest rating curve. The flood of record (1965) would have been increased from 734.4 to about elevation 735.4. The standard project flood would be increased by at least 1 foot, but no more than 2 feet. The Mississippi River has very steep valley walls in pool 1. The valley walls are very bluff-like in appearance and roughly 100 feet above low-pool. Because of the shape of the valley along pool 1, the increased stages of the standard project flood would not pose an additional safety hazard.

PUBLIC SAFETY CONSIDERATIONS

The tentatively recommended plan and its operation would pose no added safety hazards to the public.

HISTORIC PROPERTIES CONSIDERATION

During coordination with the State Historic Preservation Officer (SHPO) it was determined that the Ambursen dam was potentially eligible for the National Register of Historic Places. A formal determination of eligibility will be sought from the National Register of Historic Places. Discussions between the Corps and the SHPO on the effect of the proposed hydropower development on the Ambersen dam concluded that the undertaking will not have a significant effect upon the structure and that hydropower development at locks and dam 1 is consistant with the historic purpose intended for the original project.

REAL ESTATE REQUIREMENTS

Easements

The construction of the tentatively recommended plan would be Federal property. Much of the project construction would be within the existing Ambursen Dam and the dam apron. The remaining construction

would occur just downstream of the dam apron. The location of the project on the dam apron would reduce the effective flow capability of the dam spillway. Plate 8 shows the effect of this plan on the crest rating curve. During larger flows on the Mississippi River, the tentatively selected plan could increase the pool elevation by up to one foot. However, no additional flowage easements would be needed because the increased stages fall within the limits of the existing navigation project.

Approximately 1 acre would be needed for a temporary work area easement. Construction access would be via barge or the existing Ford Motor Company access road to the existing plant (see plate 5). Ford Motor Company owns the land surrounding the east end of the dam. The temporary work area easement is estimated to cost $10,000.

Materials Disposal Area

The tentatively recommended plan would also require a disposal site for excavated material. An existing site referred to as the Port of Minneapolis Upper Harbor site would be used. It has been estimated for planning purposes that a 1-acre disposal site would need to be acquired for a temporary easement. Approximately 30,000 cubic yards of excess material could be stored for a period of 6 months. The material would be used by private contractors, free of charge, and could all be removed from the site within the 6-month period. The temporary easement would cost approximately $10,000.

In the event the Minneapolis site is temporarily filled to capacity, another site exists near the High Bridge in St. Paul.

Material excavated from the locks and dam 1 site could be barged to either disposal site within the unit costs shown in the project construction cost estimates. Disposal of excavated material at these

sites, which are both above the ordinary high watermark, would be coordinated with the State of Minnesota.

Total Real Estate Requirements	
Construction easements	$10,000
Materials disposal area	10,000
Total	20,000

SENSITIVITY ANALYSIS

The North Pacific Division accomplished a partial sensitivity analysis on the tentatively recommended project. They varied the discount rate and period of analysis as shown on the following table. The other significant economic factors are discussed only in general terms in the following paragraphs.

Comparison: Interest Rates and Periods of Economic Analysis (for 7.2 MW Selected Size, Site C)

Interest Rate (Percent)	Annual Cost ($1,000)	Annual Benefit ($1,000)	Net Benefit ($1,000)	Benefit-Cost Ratio
100-Year Period of Analysis				
8 1/8	1,035	1,151	116	1.11
14	1,870	1,151	-719	0.62
50-Year Period of Analysis				
8 1/8	1,054	1,151	97	1.09
14	1,872	1,151	-721	0.61

Fuel Escalation Factor

The factor has varied from 2.4 in 1982 to 1.7 in 1983. Such a wide variance in the factor has a significant effect on the project economic feasibility. However, the project remains feasible even with the escalation factor being severely depressed. Information from FERC indicates that the fuel escalation factor should begin increasing,

causing stronger project feasibility, beginning sometime between the years 1990 and 2000.

Capacity Benefit Power Values

This site has a relatively low dependable capacity. Therefore, changes in the capacity benefit power value have limited effect on the project economic feasibility.

Energy Benefit Power Values

This factor accounts for about 80 to 90 percent of the hydropower project benefits. Thus, changes in this power value factor can have drastic effects on project economic feasibility.

Operational Assumptions

This analysis assumed that "first water" was supplied to the existing hydropower project. An operational agreement with Ford Motor Company to maximize the generation derived from a given flow would significantly increase the benefits for the proposed Federal project. That type of arrangement would strengthen the economic feasibility of the proposed project.

Project-on-Line Date

The project-on-line (POL) date can have a significant effect on the adjusted power values used to compute project benefits. The current POL date is 1990. A later POL date, such as 1995 or 2000, would enhance the project feasibility. An escalation factor, used to reflect increasing energy prices, is projected to increase after 1990. The recent oil glut is thought to be only temporary, and prices are expected by FERC to continue climbing for at least the next two decades after 1990.

HYDROLOGIC POWER AND ENERGY ANALYSIS

Average Annual Energy

The power potential at this site was determined using the North Pacific Division's Power Duration Plot Program (DURAPLOT). This computer program analyses daily average flow, forebay and tailwater data, and constraints associated with various sized power installations. The program produces monthly and annual flow duration curves and corresponding power-duration curves. The curves are included in this report as part of the NPD turbine technical report. All data are based on daily historic flows and are for flow and generating head ranges of specific turbine generator sizes. The available power potential was that which would be available over and above that presently generated by the existing facilities.

The locks and dam 1 site works in both a winter (December, January, and February) and a summer (July and August) peak system. The summer load is the more critical of the two.

GEOLOGY AND FOUNDATIONS

Available subsurface data at the proposed hydropower site is from borings taken for the rehabilitation of lock and dam 1 in 1974. The boring locations and boring logs are shown on plates 6 and 3, respectively. Boring 82-1M was taken in 1982 to evaluate the alternate A powerhouse location. A detailed stratigraphic column of the project area is shown on plate 10. The stratigraphic column was developed from a deep boring taken on top of the right bluff. At the alternate C powerhouse location, all units above unit B have been eroded with subsequent deposition of approximately 35 feet of alluvial sands and gravels. The boring logs indicate that the powerhouse will be

underlain by 10 to 30 feet of alluvial sands, gravels, and boulders that are underlain by bedrock. A typical cross section of the existing structure is shown on plate 9.

The major geotechnical concerns are the powerhouse foundation, the cofferdams required for construction, and dewatering of the construction site. Piling will be required to provide an adequate foundation for the powerhouse and headwall. The piling will be 10 to 30 feet long and will bear on the rock underlying the alluvial deposits. Dewatering the construction site will require upstream and downstream cofferdams connected by temporary walls extending over the crest of the existing Ambursen dam. The temporary walls are required to prevent flows over the dam from spilling laterally into the construction area. Sheet-pile cell cofferdams will be used for both the upstream and downstream cofferdams. Rock fill previously placed downstream and upstream of the dam will have to be excavated prior to driving the sheet-pile cells. Other items of concern with respect to the cofferdams are the tie-ins between the existing Ambursen dam and the sheet-pile cell cofferdams, sealing the "windows" between the sheet-pile cell cofferdams and the existing sheet-pile cutoff walls on the upstream side of the dam and at the end of the downstream concrete apron, and the possibility of a high rate of seepage through the rock fill placed beneath the downstream portion of the existing apron. The presence of the rock fill beneath the existing apron may preclude using sheeting and bracing of tied-back sheet pile to minimize both the excavation and the length of the downstream cofferdam. Dewatering for the downstream excavation may require both deep and shallow wells as well as sump pumps for local mop up.

A discharge channel, excavated as shown on plate 26, will be required to control the discharge from the powerhouse. Riprap protection will be required at the intake and in the discharge channel as shown on plate 2.

The stability of the existing Ambursen dam is of some concern, but is not expected to be a significant problem if the existing concrete floor is not removed.

Additional boring and testing as well as further research of design and construction records for the dam will be required in the next design phase to better define existing subsurface conditions.

MECHANICAL AND ELECTRICAL

The mechanical and electrical requirements for the proposed project are adequately described in the North Pacific Division's turbine technical report. The technical report is included in this report as an appendix.

INSTITUTIONAL ANALYSIS

KEY INSTITUTIONS

Many interests and agencies would have input to proposed hydropower development at locks and dam 1. However, several key institutions would have a major impact on any proposed hydropower development at this site. They are identified and discussed in the following paragraphs.

- Ford Motor Company (Ford) - The existing hydroelectric facilities are owned and operated by the Ford Motor Company. Ford is an investor-owned corporation. Thus, Ford would not be considered a "preference customer" under the Federal Power Act which gives preference to publicly-owned utilities for purchasing federally developed power. Ford could develop the added potential separate from Federal participation, however.

- Federal Energy Regulatory Commission (FERC) - The Federal Energy Regulatory Commission replaced the Federal Power Administration (FPA) and regulates all non-Federal power development. The FERC issues preliminary permits and licenses for power development to non-Federal agencies. In contrast, the Corps of Engineers develops power by virtue of authorization and direction of Congress and follows the established Federal Principles and Guidelines for report preparation and public involvement.

  In the case of the existing hydropower development at locks and dam 1, FERC has issued a license which governs operation of the project. The FERC project license is numbered 362. When the license expires, the licensee (Ford) must reapply for a new license. According to the Federal Power Act, when the existing

license is up for renewal, municipalities may also apply for the right to generate power at the site. The group with the "best" plan would prevail, based on the Commission's determination.

- Mid-Continent Area Power Pool (MAPP) - The MAPP organization recently assumed the responsibilities of the Mid-Continent Area Reliability Council Agreement (MARCA) Region. The MAPP/MARCA region is currently one of nine electric reliability council regions in the United States. These regions were formed in 1968 by the electric utility industry to promote the reliability and adequacy of bulk electric power supply in North America.

  The current MAPP region covers 400,000 square miles of the United States and involves 7 States, with respect to electric reliability planning and operating activities. The States involved are: the western half of Wisconsin; all of Minnesota, Iowa, Nebraska, and North Dakota; eastern Montana; and most of South Dakota. The Canadian Provinces of Manitoba and Saskatchewan are associate members of MAPP.

- Department of Energy (DOE) Power Marketing Organizations - The Department of Energy has the authority to market power produced at Federal facilities. This authority is contained in section 5 of the Flood Control Act of 1944. Currently, the DOE has five power marketing authorities in the continental United States.

  No Federal power dams have been constructed in the Great Lakes area where the locks and dam 1 site is located, so no marketing administration has been established by DOE for this area. However, DOE did establish a DOE ad hoc work group which prepared a power marketing study for the Great Lakes area in January 1981. The DOE could possibly market federally produced power at locks and dam 1 through the nearby Western Area Power Administration (WAPA).

- State Historic Preservation Office - The State Historic Preservation Office is responsible for preserving and protecting the historic values of the State.

- Cities of Minneapolis and St. Paul - The locks and dam 1 site is located between Minneapolis and St. Paul, Minnesota.

- U.S. Fish and Wildlife Service (USFWS) - The USFWS is an agency of the Department of the Interior, which is charged with safeguarding the Nation's wildlife, including migrating fish and wildlife resources and endangered species. The locks and dam 1 area supports a limited fishery. The Fish and Wildlife Service is concerned with residential fish populations and supports efforts to maintain viable tailwater fisheries in the area.

  The USFWS provides both planning assistance to the Corps in these proposed developments and a supplemental report for the study, outlining desirable fish and wildlife preservation and enhancement features.

- Minnesota Department of Natural Resources (MDNR) - The Minnesota Department of Natural Resources has the same interests as the USFWS, but at the State level. The MDNR is also charged with the responsibility for issuing permits for water use and water withdrawals within the State and for monitoring actual use.

- Environmental Protection Agency (EPA) - The Federal Environmental Protection Agency has the responsibility of protecting the Nation's land, air, and water quality.

- Minnesota Pollution Control Agency (MPCA) - The MPCA has the same responsibilities as the Federal EPA except that responsibilities are confined to State inland or boundary waters.

COORDINATION WITH INSTITUTIONS

Coordination was conducted with the aforementioned agencies, as well as other interests, through meetings, telephone calls, letters, and public notices. This coordination will continue throughout the remaining study phases and during the proposed preparation of plans and specifications and construction stages.

PLAN IMPLEMENTATION

The plan, as developed and presented herein, envisions the added power potential of the locks and dam 1 being developed by the Federal Government, with no involvement by the existing licensee, Ford Motor Company. Under this plan, the Federal Government would acquire the necessary construction easements, access, and disposal areas for constructing the new powerhouse.

The Corps of Engineers would construct the power facilities, if authorized by Congress, under the recommended plan. Once the project was constructed, the Department of Energy would market the added power, giving first preference to municipalities and cooperatives as discussed earlier in the report. The buyer of the power would be involved as the non-Federal sponsor of the project.

The proposed new power plant, operated by the Federal Government, would operate side-by-side with the existing non-Federal Ford Motor Company plant. The new plant would tie in to Northern States Power Company's transmission and distribution facilities as indicated earlier. This plan is implementable, assuming that no non-Federal group develops the added power first.

There is no indication from Ford Motor Company or from other sources that there would be any operating difficulties with the proposed Federal project operating side-by-side with the existing plant.

AD-A145 898 LOCKS AND DAM 1 (FORD DAM) MISSISSIPPI RIVER DRAFT FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT FOR HYDROPOWER(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT AUG 84 2/3

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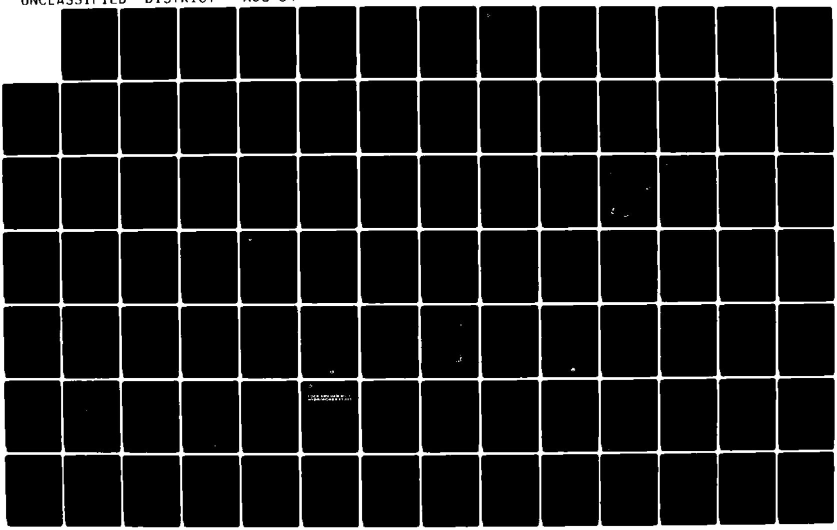

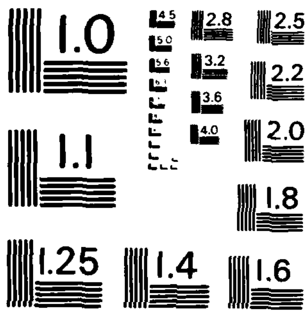

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

SUMMARY OF COORDINATION, PUBLIC REVIEW AND COMMENTS

The initial coordination for this project occurred during the reconnaissance study dated September 1981. Comments generally expressed concern for the possible environmental effects. The Minnesota Historical Society also indicated that there is little potential for significant prehistoric sites because of the degree of disturbance resulting from construction of the locks, dam, and powerhouse. However, the Ambursen dam and appurtenance works might qualify for the National Register.

Natural resource and environmental protection agencies are generally opposed to any plans that would include intentional use of storage to provide peaking power (that is, to fluctuate river pools in any manner to facilitate increased hourly power production during high daily power demand periods). Based on the public concerns, the St. Paul District Engineer determined that peaking would be inconsistent at locks and dam 1 because peaking would interfere with the existing project purposes of navigation and recreation. Therefore, peaking has not been considered in the analysis of Federal hydropower projects at locks and dam 1.

Significant comments that may be received during coordination of this draft report will be incorporated into the final report.

OTHER REQUIREMENTS

To comply with the National Environmental Policy Act, the Corps of Engineers is required to prepare an environmental assessment or environmental impact statement for the development of hydropower projects. An environmental assessment has been prepared in compliance with the National Environmental Policy Act and is a part of this document.

In addition, a 404 (b)(1) evaluation has been prepared to comply with provisions of the Clean Water Act, as amended. This analysis of the fill placement in water is required under section 404 (r) of the Act for projects submitted to Congress for authorization. If interests other than the Corps of Engineers decide to develop hydropower at the site, they will have to apply for the appropriate State and Federal permits.

Section 106 of the National Historic Preservation Act of 1966, as amended, requires all Federal agencies to assess project impacts upon National Register of Historic Places properties in consultation with the State Historic Preservation Officer and to request the comments of the Advisory Council on Historic Preservation in accordance with implementing regulation 36 CFR Part 800.

In accordance with 36 CFR Part 800.9, this document represents the St. Paul District's request for comments from the Advisory Council on Historic Preservation.

ADVANCED ENGINEERING AND DESIGN

The intent of this and other feasibility studies undertaken by the Corps is to determine whether a proposed project is, in fact, feasible to develop. The analysis done in this report indicates that there is strong economic justification for the development of hydropower at the site. There are, however, a number of considerations, not appropriate for a feasibility study, which must be addressed in subsequent advanced engineering and design studies (the next step in the Corps planning process) if it is determined that the Federal Government should develop the hydropower potential at the site. In addition, normal Federal evaluation procedures will result in further analysis of items already addressed in this feasibility study. Briefly, items of further analysis would include detailed further analysis of available flows, operation strategy, and optimum turbine size.

With regard to the implementation strategy discussed in the next section, optimization of hydropower generation may justify establishing operating agreements with Ford Motor Company. These agreements could allow the more efficient turbines proposed in this report to use the first available flows (following navigation). The existing turbines of the Ford Motor Company could then be brought on line when additional flows were adequate to operate these older, less efficient units. This option could take full advantage of electrical generation potential and give maximum flexibility. An energy exchange would be used to replace the "first water" benefits which the Ford Motor Company controls because of their FERC license.

The North Pacific Division (NPD) Hydroelectric Design Center will be involved in any advanced engineering and design. At that time, it will be necessary for NPD to verify their scoping analysis for this project, including the following factors and assumptions:

- Cooperative operation with the existing project.
- Current power values.
- Updated costs.
- Sizing, type, and number of turbines.
- Powerhouse location.

A typical feasibility study normally identifies exactly which powerhouse location has been selected for detailed engineering and design. While this feasibility report tentatively recommends a particular project, it should be understood that several other identified powerhouse locations are very close in economic feasibility to the selected project. Slight modifications to the economic factors and assumptions can change the relative NED ranking of the alternatives. For that reason, it will be necessary for NPD to review all potentially feasible projects with updated economic factors just prior to initiating the advanced engineering and design. If a

different alternative is selected as a result of the rescoping, then an new environmental assessment and 404 analysis would be required.

If additional study (at the design level) is authorized, the St. Paul District intends to work closely with Federal, State, and local interests to assure cooperative planning of hydropower and related local development. This cooperative planning is absolutely necessary.

NON-FEDERAL SPONSOR AND COST SHARING

The current administration and the Assistant Secretary of the Army for Civil Works all support responsible non-Federal hydropower development at this site. Their goal is to encourage timely and responsible hydropower development that is independent of Federal financial involvement. In the event of no timely and qualified non-Federal license application, a Federal project could be authorized for construction. Traditionally, such Federal hydropower projects have placed a large financial burden on the Federal Government. Past projects were constructed with 100-percent Federal funding and were paid back by the sponsor using below-market interest rates over a long period.

More recently, Federal water resource projects, including hydropower, have been recommended for construction with more of the up-front construction cost to be paid by the non-Federal sponsors of the projects.

COST SHARING POLICIES

Cost-sharing policies for Federal water resource development projects have been in a state of flux during the last several administrations. The amount of local (non-Federal) cooperation required depends on the nature of the project and on the general and specific laws pertaining to it.

Traditional cost-sharing agreements for hydropower facilities have generally included the following provisions:

- o 100-percent Federal construction costs.
- o Complete reimbursement by non-Federal or local sponsor, over the project life.
- o Costs for lands, easements, rights-of-way, and relocations are allocated to the project purposes and are shared on the same basis as construction costs for each purpose.
- o Operation and maintenance is a non-Federal cost.

The Secretary of the Army further proposes "up-front" financing by non-Federal sponsors. The proposed non-Federal up-front financing arrangement for hydropower projects is 100 percent.

RECOMMENDATION

Based on this report, I have concluded the following:

- o That the Nation has a continuing need for the development of power sources, in particular, hydroelectric power sources.
- o That additional power can be developed at locks and dam 1 in a manner that is engineeringly sound, economically feasible, environmentally acceptable, and compatible with navigation and other public uses of the Upper Mississippi River.

- In the event that the existing licensee, Ford Motor Company, or another non-Federal entity does not apply to FERC for rights to develop the additional hydropower, it would be in the public interest for the Federal Government to do so.

In consideration of the above, I recommend that the addition of run-of-the-river hydroelectric facilities at the locks and dam 1 navigation project, Mississippi River, be authorized for implementation generally in accordance with the proposed plan, with such modifications as in the discretion of the Chief of Engineers may be advisable, including an appropriate number and size of units, and in accordance with cost recovery, cost sharing, and financing arrangements satisfactory to the President and Congress. The total investment cost of the project, based on October 1983 price levels, is estimated at $11,607,000, with interest, amortization, annual operation and maintenance, and replacement costs presently estimated at $1,035,000.

I further recommend that, in accordance with the Administration's policy of support for development by a qualified non-Federal interest, the authorization of this project for Federal construction be without prejudice to completion of action on a permit issued or license application under consideration by the Federal Energy Regulatory Commission at the time of authorization.

EDWARD G. RAPP
Colonel, Corps of Engineers
District Engineer

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT. CORPS OF ENGINEERS
1135 U S POST OFFICE & CUSTOM HOUSE
ST PAUL. MINNESOTA 55101

REPLY TO
ATTENTION OF:

Environmental Resources Branch
Planning Division

FINDING OF NO SIGNIFICANT IMPACT

In accordance with the National Environmental Policy Act of 1969, the St. Paul District, Corps of Engineers, has assessed the environmental impacts of the following project.

LOCKS AND DAM 1 HYDROPOWER
MISSISSIPPI RIVER, MINNEAPOLIS-
ST. PAUL, MINNESOTA

The intent of the project is to provide additional hydroelectric generating capability at St. Anthony Falls. There are two operational plants and one abandoned generating plant in the vicinity. The proposed action calls for the installment of two vertical shaft propeller turbines at the upper falls location (50-foot head) and a horizontal, adjustable blade bulb turbine at the lower falls location. A description of the proposed action may be found in section 1.00 of the environmental assessment.

The finding of no significant impact is based on the following factors: pool fluctuations would not exceed existing levels; terrestrial habitat would not change; aquatic habitat impacts would be minimal and be offset by the placement of riprap in tailraces; dissolved oxygen depletion would not be significant; tailwater flows would not be altered appreciably; turbine mortality of larval fish would not be appreciable; visual resources would be maintained; and the design of the powerhouse and channels would be consistent with the historic character of the St. Anthony Falls Historic District. See section 5.00 of the assessment for a discussion of impacts.

The environmental review process indicates the proposed action does not constitute a major Federal action significantly affecting the human environment. Therefore, an environmental impact statement will not be prepared.

Date

Edward G. Rapp
Colonel, Corps of Engineers
District Engineer

DRAFT

ENVIRONMENTAL ASSESSMENT

LOCK AND DAM 1 HYDROPOWER

MISSISSIPPI RIVER

MINNEAPOLIS-ST. PAUL, MINNESOTA

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LOCK AND DAM 1 HYDROPOWER

MISSISSIPPI RIVER

MINNEAPOLIS-ST. PAUL, MINNESOTA

1.00 SUMMARY

Major Findings and Conclusions

1.01 This study was conducted to determine the feasibility of providing additional hydropower generating capability at locks and dam 1. Five structural alternatives were identified. The alternative that would best satisfy the planning objectives and that is the tentatively recommended plan is the removal of several units of the sectional dam and installation of a powerhouse combining a 7.2-megawatt (MW) tube turbine unit.

1.02 An environmental review of the proposed action has been conducted. Because this review indicated that the tentatively recommended project would not have a significant effect on the environment, an environmental impact statement will not be prepared.

Relationship to Environmental Requirements

1.03 The selected plan has been considered in relationship to, and for compliance with, a number of Federal, State, and local laws and policies (table EA-1), including the Fish and Wildlife Coordination Act of 1958; the National Historic Preservation Act of 1966, as amended; the National Environmental Policy Act of 1969; the Clean Water Act of 1977; Executive Orders 11988 and 11990; the Endangered Species Act of 1973, as amended; the Land and Water Conservation Act of 1965, as amended; and the Reservoir Salvage Act, as amended by Public Law 93-291.

Table 1 - Relationship of plan to environmental protection statutes and other environmental requirements.

Federal statutes:	
Archeological and Historic Preservation Act, as amended, 16 U.S.C. 467 *et seq.*	FC[1]
Clean Air Act, as amended, 42 U.S.C. 7401, *et seq.*	FC
Clean Water Act, as amended (Federal Water Pollution Control Act) 33 U.S.C. 1251 *et seq.*	FC
Coastal Zone Management Act, 16 U.S.C. 1451, *et seq.*	NA[2]
Endangered Species Act, as amended, 16 U.S.C. 1531 *et seq.*	FC
Estuary Protection Act, 16 U.S.C. 1221, *et seq.*	NA
Federal Water Project Recreation Act, as amended, U.S.C. 661 *et seq.*	FC
Fish and Wildlife Coordination Act, as amended, U.S.C. 661 *et seq.*	FC
Land and Water Conservation Fund Act, as amended, 16 U.S.C. 4601-4601-11 *et seq.*	FC
Marine Protection Research and Sanctuaries Act, 22 U.S.C. 1401 *et seq.*	NA
National Historic Preservation Act, as amended, 16 U.S.C. 470 a, *et seq.*	FC
Rivers and Harbors Act, 33 U.S.C. 401 *et seq.*	FC
Watershed Protection and Flood Preservation Act, 16 U.S.C. 1001, *et seq.*	NA
Wild and Scenic Rivers Act, as amended, 16 U.S.C. 1271, *et seq.*	NA
Executive Orders, memoranda, etc.	
Floodplain Management (E.O. 11988)	FC
Protection of Wetlands (E.O. 11990)	FC
Environmental Effects of Major Federal Actions (E.O. 12114)	NA
Analysis of Impacts on Prime and Unique Farmlands (CEQ Memorandum, 30 Aug 76)	FC
State and local policies	
Minnesota State Water Quality Standards	FC
Land use plans	
None	
Required Federal entitlements	
None	

(1) FC - Full compliance.
(2) NA - Not applicable.

2.00 NEED FOR AND OBJECTIVES OF ACTION

2.01 The installation of run-of-the-river hydropower at locks and dam 1 is proposed to fully utilize the generation potential of the site. The study was authorized by a resolution of the House Committee on Public Works dated December 11, 1969.

3.00 ALTERNATIVES

3.01 Four structural alternatives were considered in detail. These were the feasible alternatives among a larger group that differed only in location, turbine type, or turbine size. Structural alternatives included two that would route flow around the existing powerhouse: plan A, which would involve an open cut between the existing powerhouse and the bluff; and plan B which would involve tunneling through the bluff. Plan C and D would both be placed in the dam itself. Because peaking is inconsistent with present project purposes, it was not considered as an alternative.

No Action

3.02 There is hydroelectric generating potential at locks and dam 1 that is not presently utilized. If the future economic climate shifts to make hydropower development even more feasible from a fiscal standpoint than at present, private interests may move to develop hydropower. The owners of the existing facility, Ford Motor Company, could decide to renovate the existing plant for greater capacity or to develop a new plant at the site. However, unless sufficient economic incentives become available, hydropower development would not occur.

Alternative A

3.03 This alternative would be developed by excavating the open space between the Ford powerhouse and the bluff and by installing a 16-MW bulb turbine. The intake would be within the log boom around the intake of the Ford plant and would be set at 687.0 feet above mean sea level (msl). The water surface would be 725.1 feet msl. The tailrace would be armored with riprap and would be angled to merge with that of the Ford plant (plate 6).

Alternative B

3.04 Alternative B is identical to A in all respects except its location and elevation. The powerhouse would be underground within the sandstone bluff. A tunnel would provide water to the power plant from the upstream side of the Ford plant. The intake would be set at 704.0 feet msl (plate 7).

Alternative C

3.05 This plan would consist of one tube turbine unit of 7.2 MW, total, in a powerhouse that would replace part of the dam. The dam is an Ambursen type that was built in adjacent sections, several of which may be removed for installation of the powerhouse intake. Most of the powerhouse would rest on the dam apron separated by about 70 feet from the Ford powerhouse. The intake would rest on the river bottom at 693.6 feet msl (plate 6).

Alternative D

3.06 A single bulb turbine placed in the dam, as described above, would constitute alternative D. This unit would be set at 672.0 feet msl, which is much deeper than the tube turbine. The tailraces

of C and D would be angled to merge with the Ford tailrace to avoid the island downstream of the dam (plates 6 and 7).

4.00 ENVIRONMENTAL SETTING

4.01 Locks and dam 1 is at mile 847.6 (above the Ohio River) on the Mississippi River, approximately 3.5 miles upstream of its confluence with the Minnesota River. The river, at the dam, separates the cities of St. Paul and Minneapolis, Minnesota.

4.02 The dam is situated in a 100-foot-deep gorge formed by glacial pressure and the retreating St. Anthony Falls. The bluff tops are approximately 1,200 feet apart. The river is approximately 900 feet wide at the dam, but narrows quickly to 200 feet a short distance downstream of the dam and remains narrow to the junction of the Minnesota River. Navigation pool 1 extends upstream to the lower dam at St. Anthony Falls (river mile 853.4) in downtown Minneapolis. Water passing over the dam enters pool 2, which extends downstream to lock and dam 2 at Hastings, Minnesota (river mile 815.2).

4.03 The area on the bluff top is occupied by the Minnesota Veterans Home and Minnehaha Park. The park extends downstream to the junction with Minnehaha Creek near mile 844. A Ford Motor Company assembly plant is located on the St. Paul side. Ford also maintains the hydroelectric plant at the east end of the dam and the flashboards on the crest.

Terrestrial Resources

4.04 The slope and bluff vegetation in the project area is composed of a mixture of typical river slope and woody species. Open grassy slopes, interspersed with trees and shrubs, occur on the west bank immediately adjacent to locks and dam 1. The prevalent tree species are American elm (*Ulmus americana*) and cottonwood (*Populus sp.*).

Other representative species include silver maple (Acer saccharinum), sugar maple (Acer saccharum), green ash (Fraxinus pennsylvanica, and sumac (Rhus typhina).

4.05 The island below the dam supports the remnant of a young floodplain forest stand which is representative of early bottomland woody successional stages in central Minnesota. Significant amounts of sandy silt have been deposited at the downstream end of the island. It appears that periodic high river flows, with concomitant recurring cycles of deposition and erosion, will maintain the present surface species composition of the island. However, changes in the relative abundance and age groupings of species will occur in response to fluctuations in annual flows.

4.06 The island is used by turtles, migrating birds, and nesting birds (including waterfowl, shorebirds, and songbirds). Terrestrial habitat is otherwise limited by the steep bluff slopes. The small area, low vegetation, and spring flooding would discourage mammals from colonization.

Aquatic Resources

4.07 Historically 47 species of fish have been found in pool 1 and 46 in pool 2. Of these, 24 (pool 1) or 25 (pool 2) were common, and 5 in each pool were abundant. Common species include: gar (Lepisosteus sp.), bowfin (Amia calva), mooneye (Hiodon tergisus), northern pike (Esox lucius), carpsucker (Carpiodes sp.), white sucker (Catostomus commersoni), bigmouth buffalo (Ictiobus cyprinellus), catfish (Ictalurus sp.), white bass (Morone chrysops), rock bass (Ambloplites rupestris), largemouth bass (Micropterus salmoides), black and white crappies (Pomoxis sp.), yellow perch (Perca flavescens), sauger (Stizostedion canadense), walleye (S. vitreum), freshwater drum (Aplodinotus grunniens), and several forage species. Abundant species include: gizzard shad (Dorosoma

cepedianum), carp (*Cyprinus carpio*), river (*Notropis blennius*) and emerald shiners (*Notropis atherinoides*), and bluegills (*Lepomis macrochirus*) (Rasmussen, 1979).

4.08 The urban and industrial development of the area around locks and dam resulted in the lock and dam construction, changes in pool levels and flows, dredging, barge traffic, and combined sewer overflows. Because of this, habitat for aquatic life has been reduced. The oxygenation of water by the dams and recent efforts to improve water quality somewhat offset these habitat losses. Fish populations are limited in the pool because of the lack of shallow water habitat for spawning, nursery, and feeding; the pool's small size; and occasional short periods of poor water quality. Commercial fishing is not practiced but recreational fishing is popular in the area due to the proximity of the urban area. However, the Minnesota Health Department advises that fish consumption be limited because of high levels of mercury and polychlorinated biphenyls. Specifically, no more than 1 meal per month should be eaten of carp or bigmouth buffalo taken from pool 1 (above the dam). Only half that amount should be eaten by young children and pregnant or nursing women.

Water Quality

4.09 The quality of water passing over locks and dam 1 is generally good but may be degraded by the overflow of combined sanitary and storm sewers. High levels of organic materials and fecal coliform bacteria occur in the river after heavy rainfalls. Dissolved oxygen levels are high, often exceeding saturation, because of the aeration of the dams at St. Anthony Falls and locks and dam 1. Turbidity is generally low, increasing during periods of stormwater runoff. Water quality is considerably degraded below the confluence with the Minnesota River because of the turbidity and bacteria contributed by that river. The section of river from St. Anthony Falls to the

Metropolitan Wastewater Treatment Plant, including the locks and dam 1 site, is classified 2B by the Minnesota Pollution Control Agency. This means that water should be of a quality suitable to support cool-water and warm-water fisheries, communities, and recreational uses (e.g., hunting, fishing, water sports). The classifications are explained in the Minnesota Code of Agency Rules, WPC-14, 15, and 25.

Endangered and Threatened Species

4.10 Species on the Federal list of endangered and threatened species could occur in the project area. The bald eagle (Haliaeetus leucocephalus) and the Arctic peregrine falcon (Falco peregrinus) may migrate through the project area or be present in a transient status in the spring and fall. The Mississippi River supports endangered mussels in some locations but there are none in the project area because of poor water quality. No State endangered or threatened species are in the project area.

Existing Recreation Resources

4.11 Other than dredged material disposal sites located within the pool, there is a lack of beach areas and other areas suitable for recreation development. Both riverbanks in pool 1 are in public ownership, with automobile parkways and trails paralleling the river. Hidden Falls Park is downstream of the dam on the St. Paul side of the river. The park facilities include picnicking areas, a boat launch, and trails. Farther downstream is Fort Snelling State Park with facilities for swimming, picnicking, interpretation, boat launching, and trails.

4.12 Locks and dam 1 was recently rehabilitated. As part of that project, extensive visitor facilities were provided. There is a system of catwalks that allows the public access to the riverward

lock wall, and excellent vantage points for viewing the dam and the powerhouse. Visitation to the Corps visitor facilities in 1983 was 45,300.

Future Recreation Demand

4.13 Recreational use of the project area is expected to continue to increase. Because land-based activities are currently limited by existing facilities and limited resources, the water-based uses such as boating will show the greatest increase in total use.

Cultural Resources

4.14 No prehistoric archeological sites are known within the pool 1 area. The archeological sites along the river that are closest to locks and dam 1 are two burial mound groups in Mendota Heights (upper pool 2). Any prehistoric archeological resources that may have existed at locks and dam 1 were likely destroyed during construction of the facility.

4.15 Historic sites in the area are associated with the settlement and development of the Twin Cities. Sites range from military period Fort Snelling to residential houses, commercial buildings, and engineering structures such as the Mendota Bridge and locks and dam 1 itself.

5.00 NATIONAL REGISTER OF HISTORIC PLACES PROPERTIES

5.01 In accordance with the National Historic Preservation Act of 1966, as amended, the National Register of Historic Places was consulted. As of March 1, 1984, two historic properties were immediately adjacent to locks and dam 1. The Minnesota Soldiers Home has been determined eligible for the National Register, and the Minnehaha Park Historic District has been listed on the National

Register. Initial coordination with the Minnesota State Historic Preservation Officer (MSHPO) identified locks and dam 1 as a structure potentially eligible for the National Register, even though the locks have been significantly modified in recent years. A copy of a letter from the MSHPO dated May 14, 1984, is included at the end of this environmental assessment. Briefly, the letter says that the MSHPO considers the proposed project to be an adoptive reuse of the existing structure that is consistent with its authorized purposes.

Minnesota Soldiers Home

5.02 The Minnesota Soldiers Home is located on 51 acres adjacent to Minnehaha Creek and the Mississippi River. The home was constructed because the care provided to disabled Civil War veterans through national legislation was inadequate. During their 1886 annual encampment, the Department of Minnesota Grand Army of the Republic passed a resolution to provide care through the establishment of a soldiers home. It was noted that there were over 30,000 disabled Minnesota veterans and that thousands were being turned away by national homes because of overcrowding. The Minnesota State legislature passed a bill supporting a State home in March 1887.

5.03 There was stiff competition for the home site, but the city of Minneapolis finally won with its 51-acre tract. In addition to this tract, the city established a public park of greater than 100 acres adjacent to the home.

5.04 Funding from the legislature did not allow for construction until 1889; therefore, a temporary home was established by leasing nearby buildings. Between 1888 and 1891, more than $200,000 was allocated by the legislature for construction of the home.

5.05 The buildings were of a uniform architectural style, built of

brick with brown stone trim and slate roofs. The buildings were designed by Minneapolis Architect W.B. Dunnell, and the plan for the home was well thought out so that additions could be made that would blend well with the original design (extracted from the Determination of Eligibility Form prepared by Charles W. Nelson, Minnesota Historical Society).

Minnehaha Park Historic District

5.06 Minnehaha Park encompasses over 100 acres of land along Minnehaha Creek from approximately Minnehaha Parkway to its confluence with the Mississippi River. Within the bounds of the park are several historic structures of significance: Godfrey's Mill, Stevens House, R.F. Jones (Longfellow) House, and the Minnehaha Station. These structures represent some of the early mills and residences of the area. The Jones House is interesting because it is a replica of the house of Henry W. Longfellow who immortalized Minnehaha Falls in his poem, "The Song of Hiawatha." The Stevens House was the first built in the original townsite of Minneapolis. Built by Colonel John M. Stevens, an assistant sutler at Fort Snelling, the house was constructed in 1849 just above St. Anthony Falls on the west bank of the river. After two previous moves, the house was finally relocated to Minnehaha Falls Park when on May 28, 1896, 10,000 school children towed the house in relays the 5 miles from downtown Minneapolis to the park. The Minnehaha Station is a small depot built in the 1870's by the Minnesota Central Railway. The company, an ancestor of the Milwaukee Road, provided service to the nearby zoo and park (extracted from the National Register Nomination Form, prepared by John Grossman, Minnesota Historical Society).

Locks and Dam 1

5.07 Locks and dam 1 was the first lock and dam complex constructed in the Upper Mississippi River lock and dam system. It was designed by Major Francis R. Shunk of the U.S. Army Corps of Engineers. The dam itself was built as a modified form of the new Ambursen type dam. It is a hollow construction with a deck of narrow reinforced concrete slabs overlying a triangular concrete buttress (see plate 9 and the photo following page 22, dated November 16, 1916). The concrete dam was constructed using both cast-in-place and mold-casting methods. The dam was 574 feet long with a 152-foot-long foundation for the powerhouse. The 30-plus-foot head at locks and dam 1 allowed Major Shunk to become the first officer of the Corps of Engineers to design and build a hydroelectric dam in the United States (Gjerde, 1983: 121). Because the Federal Government was not interested in hydroelectric generation, construction was not carried further than the powerhouse foundation. By 1912, a consortium was formed by the cities of Minneapolis and St. Paul and the University of Minnesota to negotiate with the Government for the rights to develop the lock and dam 1 site. The Federal Power Commission ultimately assigned these rights to the Ford Motor Company, with a maximum capacity of 18,000 horsepower. By July 1924, four 4,500 horsepower generators had been installed and were in operation.

5.08 Major construction at locks and dam 1 was accomplished during three periods. The initial construction was completed between 1894 and 1917. With the collapse of the lower lock gate in August 1929, the system was changed from a single lock to a double lock system. The twin locks were completed by 1932. The final major construction took place between 1979 and 1983 when the two locks were completely rehabilitated.

5.09 Even though the recent rehabilitation has considerably changed the locks, the Ambursen dam has not been modified and is considered

to be eligible for the National Register of Historic Places. It is the only fixed dam on the Upper Mississippi River, and this complex and the St. Anthony Falls Locks and Dams are the only locks and dams in the St. Paul District portion of the 9-foot navigation channel with hydroelectric facilities. Locks and dam 1 is the only dam in the District, however, that was originally authorized for both navigation and hydropower.

6.00 ENVIRONMENTAL EFFECTS

6.01 The following is a description of the effects of the proposed action. In compliance with Section 404 of the Clean Water Act, a 404(b)(1) evaluation has been prepared; it follows this environmental assessment.

6.02 The proposed action would provide additional electrical power by directing flow, which would otherwise pass over the dam, through a turbine. The potential effects of hydropower can be divided into operational and construction effects. Each will be discussed in the following paragraphs, followed by general discussions of the project effects on endangered species, Executive Orders 11988 and 11990, recreation, aesthetics, and cultural resources.

Operational Impacts

6.03 Operational impacts could include any or all of the following: entrainment, impingement, prevention of upstream movement, alteration of tailwater flow patterns, and reduction of reaeration of dissolved oxygen. Operation of a hydroelectric plant in a "peaking" mode would cause water level fluctuations both above and below the plant, which could have serious effects on fish habitat.

6.04 The use of pool level fluctuation to provide peaking power was

not considered in this study because of its potential for detrimental impacts. Only a 0.3- to 0.5-foot fluctuation, resulting from the operation of the existing facilities, would be allowed.

6.05 The dam is a barrier to upstream fish movement. Additional hydropower would not prevent fish from reaching the locks, the only avenue of upstream movement, because no velocity barriers would be created.

6.06 Adding hydropower would divert water through the turbines that would ordinarily flow over the dam. During low flow periods, the river flow would be concentrated in the power plant tailraces. This could affect fish habitat between the toe of the dam and the island. To ensure that water flow was maintained, flashboards at or near the junction of the locks and dam would be left down to allow water to spill over the dam at low flows. This water would flow parallel to the dam toward the tailraces and would provide a continuous flow through the entire area. A determination of the flow required to maintain the aquatic habitat at the toe of the dam would be made during the next phase of the study. The number of flashboards necessary to provide the desired flow would then be left down.

6.07 The passage of water over the dam results in its aeration. This maintains dissolved oxygen levels to sustain aquatic life and decomposition of organic materials. When water is diverted through turbines, this aeration may be reduced. During the next phase of the study, a determination will be made of the contribution of the dam to aeration. Features to maintain that amount of aeration will be included in the design. The method selected would depend on the amount of oxygen required. Venting of the turbine may provide adequate aeration but could substantially decrease turbine efficiency. The flow at the end of the dam where flashboards would be left down might provide sufficient aeration. If not, it may be possible to add roughness to the dam surface to cause water to

cascade, greatly increasing its ability to take up oxygen. The potential impacts of providing reaeration would be assessed during the next phase of the study.

6.08 Impingement is the trapping of fish, eggs or larvae against water intake screens of the power plants. The screens, which prevent the passage of large pieces of debris, such as logs, would also trap large fish if velocities prevented the fish from escaping from the intake area. Since the screens would have relatively large openings, they would not affect eggs or larvae. Projecting structures around the intake could funnel fish toward the screens. To minimize impingement, no such projections would be placed in the intake areas. In addition, intake velocities in the immediate intake area would be held to 2 to 3 feet per second, a speed that most large fish can successfully swim against, at least for short distances. The large volume of water required for hydropower generation compared to other power plants prevents the achievement of the lower (0.5 foot per second) velocities typically present at the intakes of steam generating plants. Since intake velocities would be reasonably low, no impacts from impingement are anticipated.

6.09 Entrainment is a process by which aquatic organisms are drawn into and pass through mechanical equipment along with the water that contains them. Several factors influence the survival of fish passing through turbines. These may include acceleration or shear forces, rapid pressure changes (cavitation), or contact with the mechanical parts. Of these, cavitation is believed to be the most serious (Bell, 1981 and Turback et al., 1981). The rapid decompression, which can damage the turbine blades, may affect the eyes or internal organs. Fortunately, cavitation may be controlled by operating the turbines at a high efficiency and locating the turbine sufficiently below the tailwater elevation. The turbines proposed for locks and dam 1 would operate above 85 percent

efficiency at all times. Studies have shown that fish passage survival roughly equals efficiency. Acceleration and shear forces would not be expected to cause significant fish mortality because horizontal low head tube turbines do not have abrupt changes in the direction of water flow. The intake would be set relatively low so the elevation change of the water from intake to discharge would not be appreciable. Striking or being struck by parts of the turbine mechanism may injure or kill fish. However, in the proposed turbine the blades, which resemble a boat propeller, are 3.6 meters in diameter, making the space between them substantial. Low speed and clearance between blades and case contribute to survival. Mortality from striking parts of the mechanism would be of much greater concern in Francis turbines. Francis turbines have many blades, spaced closely. An additional concern is that the existing turbines in the Ford hydropower plant have two runners (blade wheels) per unit.

6.10 Since mature fish can avoid being entrained, the life stage of greatest concern would be larval fish that are not free swimming. Although specific information is not available on larval fish drift between pools 1 and 2, it is known that spawning habitat is limited in pool 1. In addition, many, if not most, of the fish would be drifting during periods of above average flow and would pass over the dam rather than through the turbine since the turbine intake would be at the river bottom. For these reasons and those discussed in the previous paragraph, it is not expected that turbine mortality of fish would be significant.

6.11 Since there is an existing hydropower license, this project could only utilize flow that would be in excess of that required by the Ford plant. There is reason to believe that the proposed plant would not only be more efficient than the existing plant but would provide a higher overall survival rate of fish passing from pool 1 to pool 2. Although it is not part of the tentatively recommended

plan, it would be logical for the developer and Ford to negotiate an operating plan that would be beneficial to both in terms of operating efficiency, with the new unit having first priority.

6.12 When a bottom intake would begin to operate in pool 1, there would be the potential for the suspension and dispersal of sediment from the bottom of pool 1. However, examination of borings taken near the location of the proposed intake (plate 3) indicated that the substrate is composed of sand, gravel, and limestone blocks. Apparently, minimal siltation is occurring in pool 1, and no resuspension would be expected. Because all excavation would be within cofferdams, no material would be resuspended during construction.

6.13 Terrestrial Resources Impacts - The installation of a turbine in the dam would not affect terrestrial resources because the unit would be located in mid-river. The tailrace of the plant would be angled toward the Ford plant tailrace to avoid causing any erosion of the island below the dam. The open trench and tunnel alternatives would have their intakes in an area subject to disturbance. Their outlets would disturb a few trees adjacent to the access roadway leading to the top of the bluff. The tunnel would otherwise disturb no habitat, and the open trench would be cut through a paved parking lot. No new powerlines would be installed above ground, so no hazard to birds would be expected. Lines would pass through the dam and/or through an existing tunnel to the substation and enter the distribution system.

Construction Impacts

6.14 The environmental effects of construction are usually short term and quite localized. Dredging, usually an item of major concern, would not be required for this project. Cofferdams of clean sand, with clay cores, some behind sheet pile walls and some

in sheet pile cells, would be used to isolate the construction sites and allow dry excavation of foundations, intakes, and tailraces. Exposed areas would be lined with riprap before cofferdams would be removed. Short-term increases in turbidity may occur when cofferdams are removed, particularly where sheet pile cells are not employed. Clean fill from an upland source would be used so no long-term effects would be expected. The material would be obtained from an operating sand and gravel facility adjacent to the Mississippi River in pool 2. The material would be loaded directly to barges and transported to locks and dam 1 where it would be off-loaded by crane. Since only 6,000 yards would be needed, normal barge traffic would not be hindered by the transport of the material. Excavated material would be disposed of at the "Port of Minneapolis" site which is presently used as a disposal area for maintenance dredging. Because this is an existing disposal area and because the disposal material is reused, its use would not result in significant effects to the human and the natural environment. The Corps would, however, coordinate with the Minnesota Pollution Control Agency before using the area since materials excavated for hydropower development would likely be different than those currently being placed in the disposal area.

6.15 The proximity of locks and dam 1 to the Minnesota Veterans Home, high rise condominiums, and Minnehaha Park requires that consideration be given to minimizing construction noise. During the rehabilitation of locks and dam 1, which was recently completed, the Corps worked with the Minnesota Pollution Control Agency to monitor noise levels and select construction equipment and procedures to keep noise levels as low as possible. During the next phase of the study, monitoring data would be reviewed and, through coordination with the Minnesota Pollution Control Agency, a plan would be developed to minimize noise during construction.

Endangered or Threatened Species

6.16 The project would have no effect on threatened or endangered species because the only species which would be in the project area would be migratory birds. The immediate project vicinity would not provide roosting sites or critical habitat for the peregrine falcon or bald eagle. No new transmission lines would be required which might provide a collision hazard; only short underground connections to the existing electrical system would be required.

Executive Orders 11988 and 11990

6.17 The proposed action was reviewed with regard to Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands). This review determined that the proposed action would have no significant impacts on wetlands or on the floodplain in the project area. No wetlands are in the project area. The proposed project would not provide increased area or increased protection of the floodplain that might promote development.

Potential Effects on Recreation and the Visual Environment

6.18 None of the proposed alternatives would directly affect existing recreation uses of the area. There would be a slight adverse effect to the visual environment caused by decreased flow volume and frequency of flows over the spillway. In addition, the Fish and Wildlife Service and the Minnesota Department of Natural Resources have expressed a concern that the decreased flows may affect the fisheries immediately below the dam apron. This could affect bank fishing from the island below the dam.

6.19 The effects on the visual environment are expected to be minimal because of the visitors' current expectations. The primary

vantage point for the dam is from the Corps visitor facilities. Secondary vantage points are the Minnesota Soldiers Home, located on the bluff above the locks and slightly downstream, and across the river on the bluff near the powerhouse. Because the dam was constructed for hydropower, and because visitors to the area are aware of its use for generating power, the development of additional capacity and the resulting decrease in flows should not significantly affect the visitor experience.

Cultural Resources Impacts

6.20 Minnesota Soldiers Home and Minnehaha Park - There would be no impacts to the Minnesota Soldiers Home and the Minnehaha Park Historic District from the construction of hydropower at locks and dam 1 for any of the alternatives under study. The location of these sites on the bluff edges overlooking locks and dam 1 would greatly reduce visual impacts both during and after construction.

6.21 Locks and Dam 1 - The alternatives considered would have the following effects on the historic significance of the Ambursen dam structure.

a. No Action Alternative - The no action plan would preserve the status quo which is not impacting upon the Ambursen dam. Any private development of hydropower at this site at a later time would require compliance with appropriate Federal legislation on cultural resources through the Federal Energy Regulatory Commission permit process. This will insure that consideration is given to the significance of the Ambursen dam.

b. Alternative A - This alternative would have no effect on the Ambursen dam because all construction would take place between the existing Ford powerhouse and the Mississippi River bluff.

c. Alternative B - Impacts on the Ambursen dam from this alternative are the same as those for alternative A.

d. Alternative C - Although locks and dam 1 has been significantly altered in recent years by renovation of the locks, the Ambursen dam is considered to be eligible for the National Register of Historic Places (see discussion in Significant Resources section). The St. Paul District is preparing a determination of eligibility for submission to the National Register. Alternative C will have an impact upon the Ambursen dam that will result in the replacement of several sections of the dam (plate 9) with the proposed powerhouse. Preliminary discussions between the St. Paul District and the State Historic Preservation Office have concluded that alternative C would affect the Ambursen dam but that this effect on the dam would not be adverse. The addition of hydropower at locks and dam 1 is consistent with the original Federal project, which included hydropower in its design. The proposed powerhouse, located on the dam apron approximately 70 feet from the existing Ford powerhouse, would have a low profile and should not be visually obtrusive, especially from the upstream end. Visual effects are also minimized because the structure is significant from an engineering perspective rather than from a historic or architectural perspective that would impart a historic feeling to the viewer.

e. Alternative D - This alternative is the same as alternative C except that it replaces the tube turbine with a bulb turbine. Impacts of this alternative would be the same as those described above except that the bulb turbine may increase structural problems with the Ambursen dam. This results from the increased depth of excavation required for the bulb turbine. Depending on the nature of the design changes that would be necessary to correct these structural problems, impacts to the Ambursen dam from this alternative could be adverse.

6.22 <u>Unidentified Prehistoric Archeological Resources</u>: No prehistoric archeological sites are known within the pool 1 area. It is to be expected that prehistoric resources existed within the pool 1 area with the same frequency and distribution as outlying areas upstream and downstream of the Twin Cities. Previous construction at locks and dam 1 likely destroyed any prehistoric resources that might have been affected by construction of the powerhouse, cofferdams, and electrical and vehicular access. It is unlikely that prehistoric resources would be impacted from borrow or disposal areas. Borrow material for cofferdams would be obtained from local, established quarries. Existing disposal areas would be used for the removal of cofferdam material.

7.00 PUBLIC INVOLVEMENT

7.01 Coordination with the public and with government agencies was maintained during the planning process. The draft report, including the environmental assessment and 404(b)(1) evaluation, will be sent to interested citizens and the following agencies for their review and comment:

U.S. Fish and Wildlife Service
U.S. Soil Conservation Service
U.S. Environmental Protection Agency
National Park Service
Minnesota Department of Natural Resources
Minnesota Pollution Control Agency
Minnesota Department of Energy, Planning and Development
State Historic Preservation Officer
State Archeologist
City of Minneapolis Planning Department
Riverfront Development Coordination Board

Advisory Council on Historic Preservation
Minneapolis Heritage Preservation Commission
City of St. Paul, Planning and Economic Development
Metropolitan Council

7.02 Coordination has been conducted with the U.S. Fish and Wildlife Service and Minnesota Department of Natural Resources to explore natural resource issues associated with hydropower development (coordination letters will be attached when received).

7.03 In accordance with 36 CFR Part 800.9, this document represents the St. Paul District's request for comments from the Advisory Council on Historic Preservation.

LITERATURE CITED

Bell, M.C. 1981. Updated Compendium on the Success of Passage of Small Fish Through Turbines. Contract DACW-68-76-C-0254, U.S. Army Corps of Engineers, North Pacific Division. 335 pp.

Gjerde, J. 1983. Historical Resources Evaluation: St. Paul District Locks and Dams on the Mississippi River and Two Structures at St. Anthony Falls. Report prepared for the U.S. Army Corps of Engineers, St. Paul District under Contract DACW37-82-M-2184. 199 pp.

Rasmussen, J.L. (ed.) 1979. A Compendium of Fishery Information on the Upper Mississippi River. Second Edition. Upper Mississippi River Conservation Committee. 257 pp.

Turbak, S.C., D.R. Reichle, C.R. Shriner. 1981. Analysis of Environmental Issues Related to Small Scale Hydroelectric Development IV: Fish Mortality Resulting from Turbine Passage. Oak Ridge National Laboratory ORNL/TM-7521. 103 pp.

United States Department of the Interior

FISH AND WILDLIFE SERVICE

IN REPLY REFER TO:

St. Paul Field Office, Ecological Services
570 Nalpak Building
333 Sibley Street
St. Paul, Minnesota 55101

April 10, 1984

Colonel Edward G. Rapp
District Engineer, St. Paul District
U.S. Army Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Rapp:

This replies to your letter of March 30, 1984 concerning the potential impacts on federally endangered or threatened species from the proposed hydropower project at Lock and Dam 1 on the Upper Mississippi River at St. Paul, Minnesota. Based on information contained in your above referenced letter, we concur with your determination that the proposed project will have no effect on any federally listed endangered or threatened species.

This precludes the need for further action on this project as required under Section 7 of the Endangered Species Act of 1973, as amended. Should this project be modified or new information indicate endangered species may be affected, you should reinitiate consultation with this office.

These comments have been prepared under the authority of and in accordance with provisions of the Endangered Species Act of 1973, as amended. Service comments on this project with respect to the Fish and Wildlife Coordination Act will be provided under separate cover.

Sincerely,

James L. Smith

James L. Smith
Acting Field Office Supervisor

MINNESOTA HISTORICAL SOCIETY

14 May 1984

Mr. Wayne A. Knott
Environemntal Resources Branch
Planning Division
Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Mr. Knott:

RE: Hydropower development at lock and dam 1 (7.2 megawatt tube turbine)

MHS Referral File Number: T-111, P-251
(PLEASE REFER TO THIS NUMBER IN ALL FUTURE CORRESPONDENCE)

Thank you for the opportunity to review and comment on the above project. It has been reviewed pursuant to responsibilities given the State Historic Preservation Officer by the National Historic Preservation Act of 1966 and the Procedures of the National Advisory Council of Historic Preservation (36CFR800).

The proposal to add a new power house for a tube turbine at the Ford Dam (Lock & Dam 1) affects a structure that may be eligible for listing on the National Register. We will not address the eligibility of Lock & Dam 1 in this letter. Adding new hydroelectric capacity to this facility can be considered an "adaptive reuse" that is consistent with the facility's original and continuing function. The propopsed design for the power house is simple and functional, and the majority of the spillway is unaltered. With these considerations, we feel that the construction of the new power house will not adversely affect the historical, engineering and design qualities of the lock and dam.

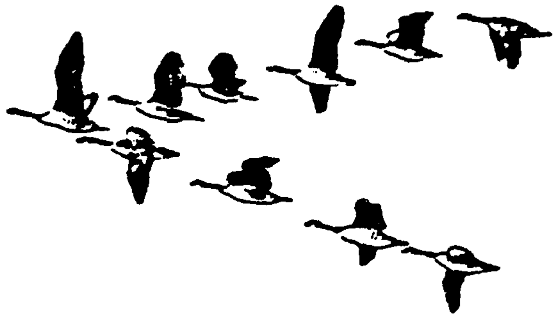
If you have any questions on our review, please contact Ted Lofstrom, Environmental Assessment Officer, Minnesota Historical Society, Fort Snelling History Center, St. Paul, Minnesota 55111.

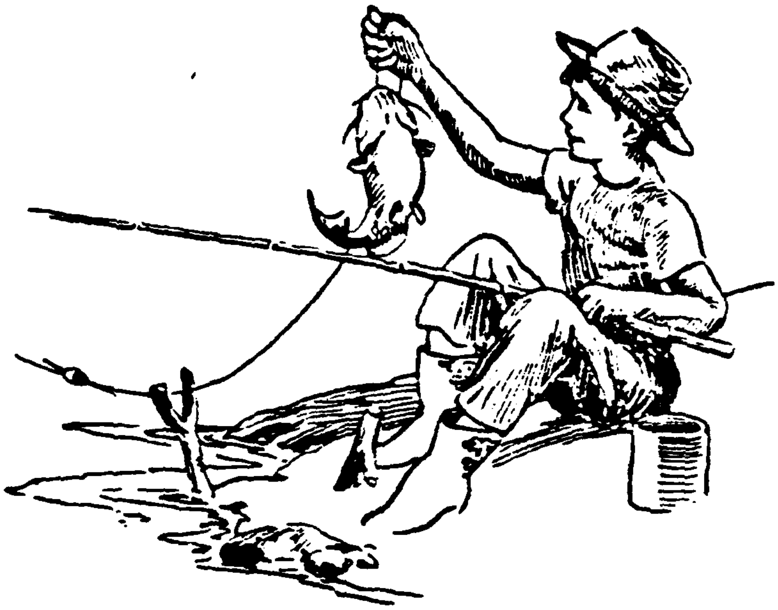
Thank you for your continued close attention to historic values in your planning process.

Sincerely,

Dennis A Gimmestad
for Russell W. Fridley
State Historic Preservation Officer

DRAFT: FISH AND WILDLIFE COORDINATION ACT REPORT





HYDROPOWER DEVELOPMENT:

UPPER MISSISSIPPI RIVER

LOCK AND DAM 2

JUNE, 1984

United States Department of the Interior
FISH AND WILDLIFE SERVICE
St. Paul Field Office, Ecological Services
570 Nalpak Building
333 Sibley Street
St. Paul, Minnesota 55101

IN REPLY REFER TO:

June 26, 1984

Colonel Edward G. Rapp
District Engineer, St. Paul District
U.S. Army Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Rapp:

This is our draft Fish and Wildlife Coordination Act (FWCA) Report for the possible construction of additional hydropower generating facilities at Lock and Dam 1 (LD1) on the Upper Mississippi River in Minneapolis and St. Paul, Minnesota. This report will generally expand on our previous comments on this project contained in our August 13, 1981 planning aid letter.

Existing Fish and Wildlife Resources

Lock and Dam 1 is located at River Mile 847.6 on the Upper Mississippi River (UMR), approximately 3.5 miles upstream of its confluence with the Minnesota River. The UMR at this location separates the cities of St. Paul and Minneapolis. The Amberson-type dam is situated in a 100-foot deep gorge; blufftops are approximately 1200 feet apart. Lands on top of the bluff are occupied by the Minnesota Veteran's Home and Minnehaha Park. A Ford Motor Company assembly plant is located on the St. Paul side of the river. Ford Motor Company also operates a hydropower plant at the east end of the dam. Existing generating capacity of this facility is 14.4 MW.

Fish and wildlife populations are somewhat limited in the Minneapolis/St. Paul pools in comparison to downstream areas primarily because of the lack of shallow water habitat, the relatively small size of the pools, and industrial development along the riverbanks. Although somewhat limited, aquatic habitat supports a diverse warmwater fishery. Valuable habitat for upland species is also provided along the wooded bluffs. The slope and bluff vegetation in the project area is composed of a mixture of upland species including cottonwood, elm, ash and silver maple. Open grassy slopes mixed with trees and shrubs are located adjacent to Lock and

Dam 1. The island below the dam supports typical floodplain forest vegetation. This island is utilized by a variety of wildlife including turtles, shorebirds and songbirds.

Sportfishing is common in Pools 1 and 2 despite the intensive urban setting. Fishery habitat is limited but generally good in Pool 2 upstream of downtown St. Paul. However, the quality of fishing and fishery habitat declines in the downstream portions of Pool 2 because of poor water quality and intensive commercial development.

Several federally listed endangered or threatened species have been known to occur in this general area of the Upper Mississippi River. The bald eagle (Haliaeetus leucocephalus), a threatened species, winters on the Upper Mississippi River, concentrating below dams or near the mouths of tributaries where fish provide a ready food supply. Also, the endangered Higgins' eye pearly mussel (Lampsilis higginsi) has been found in protions of the Mississippi and Minnesota Rivers. Historically, the endangered peregrine falcon (Falco peregrinus) has also been known to occur in this general area. Comments on endangered or threatened species have been provided under separate cover (Appendix A).

Future Setting

Fish and wildlife resources in Pools 1 and 2 have already been affected by the extensive industrial and commercial development of the downtown Upper Mississippi River corridor. In general, remaining habitats are either under public ownership as parkland or under the regulatory jurisdiction of local, state or federal agencies. Aquatic resources may actually improve in future years with the growing demand for urban water-oriented recreation and the efforts of public and private sectors to "clean up" the river. Future improvements in water quality will ultimately improve both fishery resources and recreational opportunities.

Alternative Evaluation

The following four structural alternatives for additional hydropower development at Lock and Dam 1 were evaluated by the St. Paul District. Alternative C was chosen as the selected plan for further evaluation. Alternative C will therefore be evaluated in this draft FWCA report.

Alternative A

This alternative invloves a surface excavation in the open space between the Ford powerhouse and the bluff and installing a 16 megawatt (MW) bulb turbine. The scoping process for this site also

included several other sizes of bulb turbines and two sizes of tube turbines. The proposed intake would be within the log boom around the existing intake of the Ford plant and would be set at 687.0 feet above mean sea level (msl). The water surface would be 725.1 feet msl. The tailrace would be armored with riprap and would be angled to merge with the Ford Plant tailrace.

Alternative B

Conceptually, Alternative B is identical to A except in its location and elevation. The powerhouse would be located in a tunnel within the sandstone bluff. A concrete-lined tunnel would provide water to the powerplant from the upstream side of the Ford plant. The intake would be set at 684.0 feet msl. The same turbine scoping was used for Alternative B as was discussed for Alternative A.

Alternative C

This plan would consist of installation of a 7.2 MW tube turbine unit and construction of a powerhouse which would replace part of the dam. The existing Amberson-type dam was built in sections, several of which may be removed for installation of the powerhouse intake. Most of the powerhouse would rest on the dam apron approximately 70 feet from the Ford powerhouse. The intake would rest on the riverbottom at 693.6 feet msl. Several sizes of tube turbines were considered. The 7.2 MW tube turbine was selected to maximize economic efficiency.

Alternative D

Alternative D is at the same location as Alternative C except that a bulb turbine would be used in place of a tube turbine. This unit's intake would be set at 672.0 feet msl which is much deeper than the tube turbine (Alternative C). The tailrace of C and D would be angled to merge with the Ford tailrace to avoid the island downstream of the dam and to minimize excavation of the riverbottom.

Potential Impacts and Planning Recommendations

1. Fluctuation of water levels for storage-and-release operation of hydropower facilities can adversely affect fish and wildlife resources and recreational uses both upstream and downstream of the powerhouse. Depending on minimum low flows and the frequency and duration of such operation, adverse impacts can be significant. These impacts are generally minimal under a strict run-of-river (instantaneous inflow equals instantaneous outflow) mode of operation.

Recommendation

Existing hydropower generation at LD1 utilizes a run-of-river mode of operation. To avoid and minimize additional adverse impacts to fish and wildlife resources, operation of the proposed hydropower facility should also be strict run-of-river with no storage-and-release of flows, as proposed.

2. Turbine-related mortality (impingement and entrainment) of fish is a concern with all hydropower development proposed on the Upper Mississippi River. Results of previous studies are variable and may not be applicable to hydropower development at this particular site.

Recommendation

Small trash racks or large screens should be placed in front of the intake area to prevent passage of larger fish. To minimize fishery impacts, the approach area should be devoid of lights and structural projections which would attract fish into the intake area. Recommended approach velocities for intakes at major power plants is 0.5 feet per second or less to allow fish to escape. Approach velocities at this site should be as low as possible.

Although study results are variable, we recommend use of a horizontal tube-type turbine as proposed. To minimize fish mortality, the turbine should be operated at maximum efficiency. Cavitation should be avoided if possible.

We view the proposed hydropower developments at St. Anthony Falls and LD1 as unique situations in comparison to other proposed hydropower locations on the Upper Mississippi River. At present, adverse impacts to aquatic organisms at LD1 may occur from passage through existing turbines. Unfortunately, these impacts have not been assessed. Since baseline information on fish populations is lacking, it is impossible to predict what positive or negative impacts will occur from the operation of the proposed turbine unit and associated flow diversion from the dam. In general, the absence of baseline fishery data will be a major problem in assessing impacts for all hydropower proposals on the Upper Mississippi River.

Based on the limited study information available concerning turbine mortality, the design of the proposed turbine may cause less mortality to entrained organisms than existing turbines which are of the Francis type. The Service therefore recommends

that the proposed turbine be operated in preference to the existing units when flows are insufficient for operation of all units combined.

3. Construction of the proposed project and any necessary transmission lines may impact fish and wildlife resources in the project area.

Recommendation

Construction impacts should be minimized. If dredging is required, suitable upland disposal sites must be utilized for disposal especially if the dredged material is contaminated. Turbidity and impacts to benthic organisms should be minimized. Existing transmission lines and crossings should be utilized for electrical transmission, as proposed. Debris collected on the trash rack should be removed from the river and disposed of on a suitable upland site.

4. Diversion of flows for additional hydropower generation at LD1 may adversely impact downstream aquatic resources. Due to the absence of baseline biological data for Pools 1 and 2, it is difficult to assess impacts associated with any diversion of flows for hydropower generation. Possible impacts include loss of aquatic habitat and a decrease in water quality in tailwater areas immediately below the dam.

To ensure that aquatic habitat is maintained immediately below the dam, one or more flashboards should be controlled in the vicinity of the lock to maintain a flow of water over the dam and through the immediate tailwater at low flows. During the next phase of the study, the St. Paul District in consultation with the Minnesota Department of Natural Resources and the Service should evaluate the quantity of flow necessary to maintain aquatic habitat in tailwater areas. This evaluation will determine more exactly what flashboard adjustments would be necessary to address this concern.

With respect to the quality of downstream water, the aeration of water flowing over the dam may be a significant factor in maintaining dissolved oxygen levels during portions of the year. Water diverted from the spillway for hydropower generation may therefore result in a decline in oxygen levels in downstream areas. It should also be determined whether aeration of water flowing over the existing dam spillway significantly contributes to downstream water quality. The St. Paul District should evaluate existing oxygen levels above and below the dam to determine the contribution of the dam in maintaining water

quality in downstream areas and to predict changes to existing dissolved oxygen levels due to operation of the proposed turbine. Depending on the results of the evaluation, reaeration measures may be necessary such as control of one or more flashboards to maintain flows over the dam, or venting of the turbine.

We appreciate the opportunity to offer our comments on this important project. Please contact Mr. Gary Wege (612/725-7131) of my staff if you have any questions concerning our above recommendations.

These comments have been prepared under the authority of and in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and the Service's Mitigation Policy and are consistent with the intent of the National Environmental Policy Act of 1969.

Sincerely,

Robert F. Welford

Robert F. Welford
Field Office Supervisor

Attachments

cc: MN DNR, St. Paul
MN PCA, Roseville
US EPA, Chicago

Appendices

Appendix A

United States Department of the Interior

FISH AND WILDLIFE SERVICE

IN REPLY REFER TO:

St. Paul Field Office, Ecological Services
570 Nalpak Building
333 Sibley Street
St. Paul, Minnesota 55101

April 10, 1984

Colonel Edward G. Rapp
District Engineer, St. Paul District
U.S. Army Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Rapp:

This replies to your letter of March 30, 1984 concerning the potential impacts on federally endangered or threatened species from the proposed hydropower project at Lock and Dam 1 on the Upper Mississippi River at St. Paul, Minnesota. Based on information contained in your above referenced letter, we concur with your determination that the proposed project will have no effect on any federally listed endangered or threatened species.

This precludes the need for further action on this project as required under Section 7 of the Endangered Species Act of 1973, as amended. Should this project be modified or new information indicate endangered species may be affected, you should reinitiate consultation with this office.

These comments have been prepared under the authority of and in accordance with provisions of the Endangered Species Act of 1973, as amended. Service comments on this project with respect to the Fish and Wildlife Coordination Act will be provided under separate cover.

Sincerely,

James L. Smith

James L. Smith
Acting Field Office Supervisor

PRELIMINARY

404(b)(1) EVALUATION

ADDITIONAL HYDROPOWER, LOCKS AND DAM 1,

MISSISSIPPI RIVER, MINNEAPOLIS-ST. PAUL, MINNESOTA

I. PROJECT DESCRIPTION

A. Location - The proposed addition of hydropower is at locks and dam 1, on the Mississippi River, between Minneapolis and St. Paul, Minnesota (plate 1).

B. General Project Description - The recommended plan would provide additional hydropower through the installation of a 7.2-MW tube turbine in a powerhouse that would replace part of the sectional dam (plate 6). Cofferdams and sheet pile cells would be placed to allow dry excavation and construction. Riprap would be placed during project construction to protect tailraces and shorelines from erosion.

C. Authority and Purpose - This study was authorized by a resolution of the House Committee on Public Works dated December 11, 1969.

D. General Description of Dredged or Fill Material

1. General Characteristics of Material - Fine sand or clay would be placed for cofferdams, most if not all behind sheet pile. Fine sand would also be placed in nine sheet pile cells. Riprap about 12 inches in diameter would be placed as well.

2. Quantity of Material - Approximately 10,000 cubic yards of sand and clay would be used for cofferdams and an additional 8,550 cubic yards for sheet pile cells. Approximately

2,000 cubic yards of riprap would cover about 8,000 square feet of bank and tailrace.

3. Source of Material - Sand, clay, and riprap would be obtained from local, established quarries. On-site materials would not be used.

E. Description of Proposed Discharge Sites

1. Location - Cofferdams would be placed to enclose the upstream and downstream sides of the proposed site during construction. Riprap would form part of the lower tailrace and would be placed to prevent erosion. The tailrace would be angled to join the tailrace of the existing powerhouse.

2. Size - Approximately 15,000 square feet would be covered by cofferdams and sheet pile cells. Approximately 8,000 square feet would be covered permanently by riprap, all of which would normally be under water. The cofferdams would be removed after construction.

3. Type of Site - Riprap would be placed only where required to prevent erosion. Cofferdams would be placed around portions of an existing facility to promote construction of additional hydropower.

4. Types of Habitat - Sand, gravel, and limestone blocks may be found around the construction site. Most of these areas are subjected to fast current velocities as well and would provide habitat primarily for current loving or cryptic fauna but would be limited as habitat by poor water quality.

5. Timing and Duration of Discharge - Material would be placed when practical from a construction standpoint but probably

not during a high runoff period. Sheet pile would be placed before cofferdams were constructed to prevent mixing with water.

F. Description of Disposal Methods - Riprap would be placed with a clamshell bucket. Cofferdam and cell fill would be placed with a bucket as well.

II. FACTUAL DETERMINATIONS (Section 230.11)

A. Physical Substrate Determination

1. Substrate Elevation and Slope - The substrate elevation and slope would not be changed by cofferdam placement and removal. Riprap would be placed in areas of the tailrace that would be excavated as part of the construction activities but not the fill activities. Riprap positioned around the intake would be placed directly on the river bottom.

2. Sediment Type - Sand, gravel, and limestone blocks comprise the river bottom in the area.

3. Dredged/Fill Material Movement - Sheet pile would be placed to prevent the movement of fill material. Riprap would be of sufficient size to resist movement.

4. Physical Effects on Benthos - Some benthic organisms would be destroyed by the placement of cofferdams. The large riprap may provide a net increase in available habitat because of large interstitial spaces provided.

5. Other Effects - No other effects are expected.

6. Actions Taken to Minimize Impacts - Because impacts would be minimal, no further actions would be necessary.

B. Water Circulation, Fluctuation, and Salinity Determinations

1. Water

a. Salinity - Not applicable.

b. Water Chemistry - No soluble materials would be placed in the water.

c. Clarity - Short-term, minor decreases in clarity may occur when cofferdams are placed and removed, particularly where sheet pile is not used.

d. Color - No change expected.

e. Odor - No change expected.

f. Taste - No change expected.

g. Dissolved Gas Levels - No change expected.

h. Nutrients - No soluble materials would be placed in the water.

i. Eutrophication - No soluble materials would be placed in the water.

j. Others as Appropriate - No soluble materials would be placed in the water.

2. Current Patterns and Circulation

a. Current Patterns and Flow - These would be changed by the installation of turbines but not appreciably by riprap or cofferdams.

b. Velocity - Main channel velocities would not be appreciably altered.

c. Stratification - Stratification does not occur in the project area.

d. Hydrologic Regime - The hydrologic regime would not be changed by this project.

3. Normal Water Level Fluctuations - No change would occur in water level fluctuations.

4. Salinity Gradients - Not applicable.

5. Actions That Will be Taken to Minimize Impacts - No specific actions to minimize impacts would be required since impacts would be minimal. Construction techniques would be selected to avoid causing additional impacts.

C. Suspended Particulate/Turbidity Determinations

1. Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Disposal Site - No change in suspended particulates and turbidity levels would be expected at the cofferdams that are isolated by sheet pile before filling. Short-term elevations of suspended particulates and turbidity levels could occur where unprotected cofferdams were installed and later removed, but only if river levels were high. Cofferdams would be left unprotected only where sheet pile could not be driven, such as on the dam apron.

2. Effects on Chemical and Physical Properties of the Water Column

a. Light Penetration - Short-term decrease when unprotected cofferdams are installed or removed.

b. Dissolved Oxygen - No effect expected.

c. Toxic Metals and Organics - No effect expected.

d. Pathogens - No effect expected.

e. Aesthetics - No effect expected.

f. Others as Appropriate - Not applicable.

3. Effects on Biota

a. Primary Production, Photosynthesis - No effect expected.

b. Suspension/Filter Feeders - No effect expected.

c. Sight Feeders - No effect expected.

4. Actions Taken to Minimize Impacts - None required.

D. Contaminant Determinations - No introduction, relocation, or increase in contaminants would result from the activity.

E. Aquatic Ecosystems and Organism Determinations

1. Effects on Plankton - No effect expected.

2. Effects on Benthos - Some organisms and their habitat would be destroyed by the placement of riprap. The rock would provide improved habitat over that of sand or silt on the river bottom.

3. Effects on Nekton - No effect expected.

4. Effects on Aquatic Food Web - No substantial or long-term effects on the aquatic food web are expected.

5. Effects on Special Aquatic Sites - No effect expected.

6. Threatened and Endangered Species - No effect expected.

7. Other Wildlife - No effect expected.

8. Actions to Minimize Impacts - None required.

F. Proposed Disposal Site Determinations

1. Mixing Zone Determinations - Not applicable; material would not be dispersed.

2. Determination of Compliance with Applicable Water Quality Standards - No water quality alterations would occur.

3. Potential Effects on Human Use Characteristics

a. Municipal and Private Water Supply - No effect expected.

b. Recreational and Commercial Fisheries - No effect expected.

c. Water-Related Recreation - No effect expected.

d. Aesthetics - Neither the cofferdams nor the riprap would appear natural, but the cofferdams would be removed after construction. Riprap prevents erosion, however, and erosion is not aesthetically appealing.

e. Parks, National and Historical Monuments, and Similar Preserves - No effects expected.

G. Determination of Cumulative Effects on Aquatic Systems - No cumulative effects are expected.

H. Determination of Secondary Effects on the Aquatic Ecosystem - No secondary effects expected.

III. FINDINGS OF COMPLIANCE WITH RESTRICTIONS ON DISCHARGE

The proposed placement sites for fill material comply with the requirements of the Section 404(b)(1) guidelines. No significant adaptations of these guidelines were made relative to this evaluation.

The placement of cofferdams is the most practical way to isolate the construction area and would have the least impact of any available method.

State water quality standards and toxic effluent standards would be met because no soluble material would be placed in the water. Short-term increases in turbidity may occur when unconfined cofferdams are placed and removed. The proposed actions would not violate Section 307 of the Clean Water Act.

The placement of riprap and cofferdams would not affect any endangered or threatened species or their critical habitat.

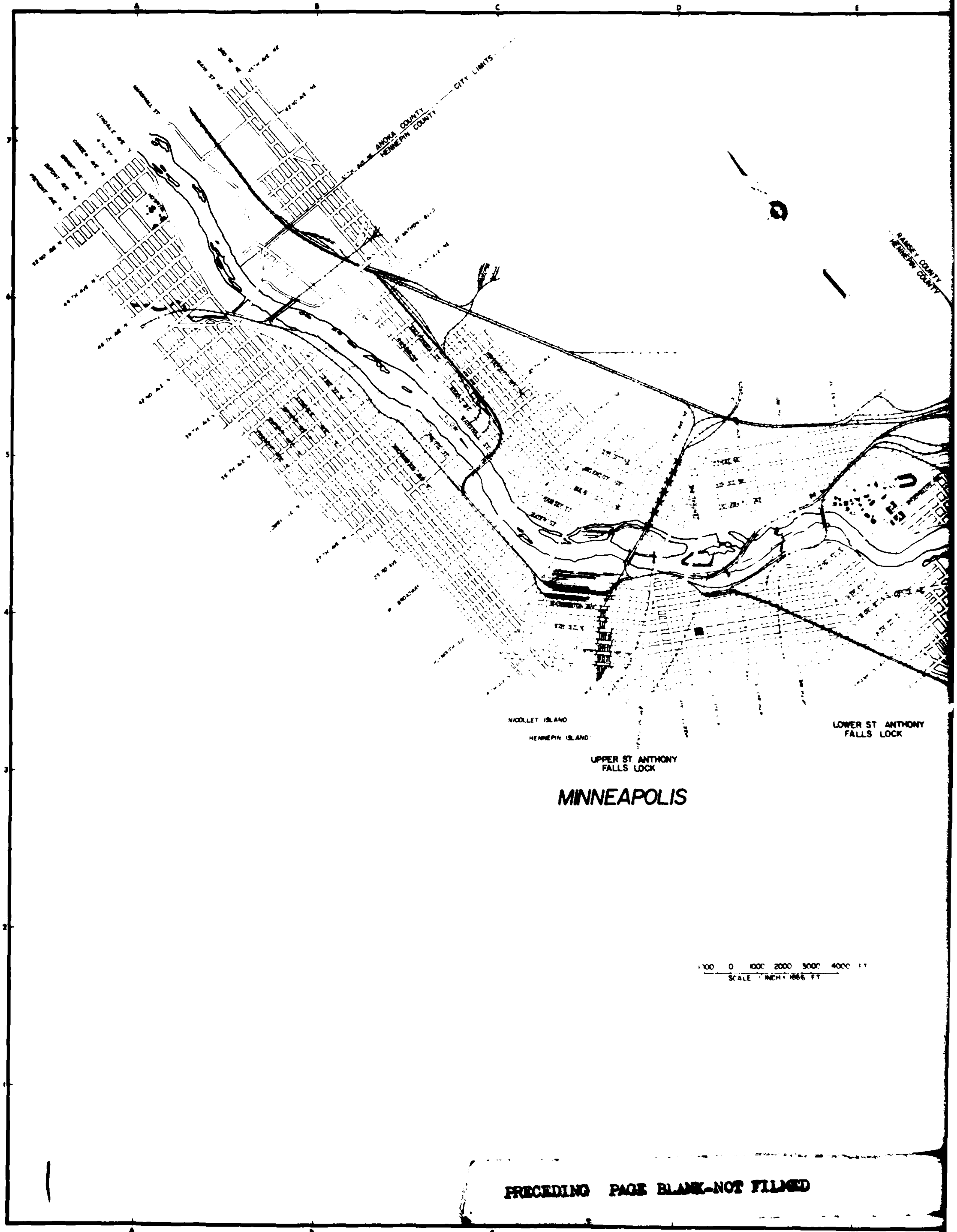
Since the only potential impact would be minor, short-term increases in turbidity resulting from suspension of clean material, the placement of riprap and cofferdams would not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreation and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. The life stages of aquatic life and other wildlife would not be adversely affected. Significant adverse effects on aquatic ecosystem diversity, productivity, and stability, and on recreational, aesthetic, and economic values would not occur.

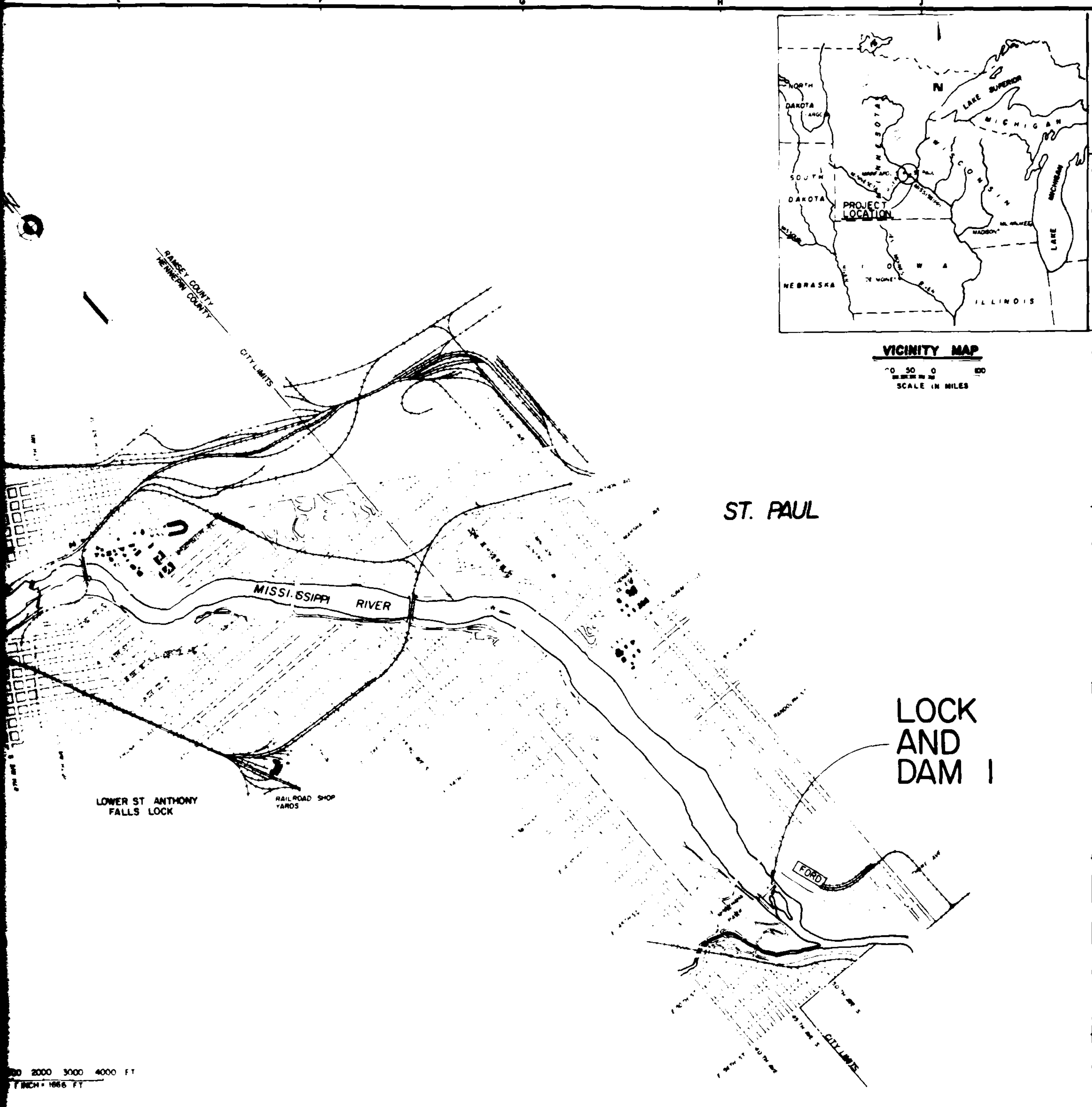
The use of sheet pile on the river side of cofferdams would minimize potential adverse impacts from placement and removal of most of the cofferdams. No other measures were necessary.

On the basis of the guidelines, the proposed placement of riprap and cofferdams is specified as complying with the requirements of the 404(b)(1) guidelines.

27 June 1984
Date

for Edward G. Rapp, LTC, CE, DDE
Colonel, Corps of Engineers
District Engineer


ANOKA COUNTY
HENNEPIN COUNTY
CITY LIMITS
RAMSEY COUNTY
HENNEPIN COUNTY
NICOLLET ISLAND
HENNEPIN ISLAND
UPPER ST. ANTHONY
FALLS LOCK
LOWER ST. ANTHONY
FALLS LOCK
MINNEAPOLIS



Note Source cg Dwg STA-O/1

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT CORPS OF ENGINEERS
ST PAUL MINNESOTA

DESIGNED BY
DRAWN BY
CHECKED BY
SUBMITTED BY
APPROVED

MISSISSIPPI RIVER
LOCK AND DAM NO 1

LOCATION MAP

HYDROPOWER FEASIBILITY STUDY

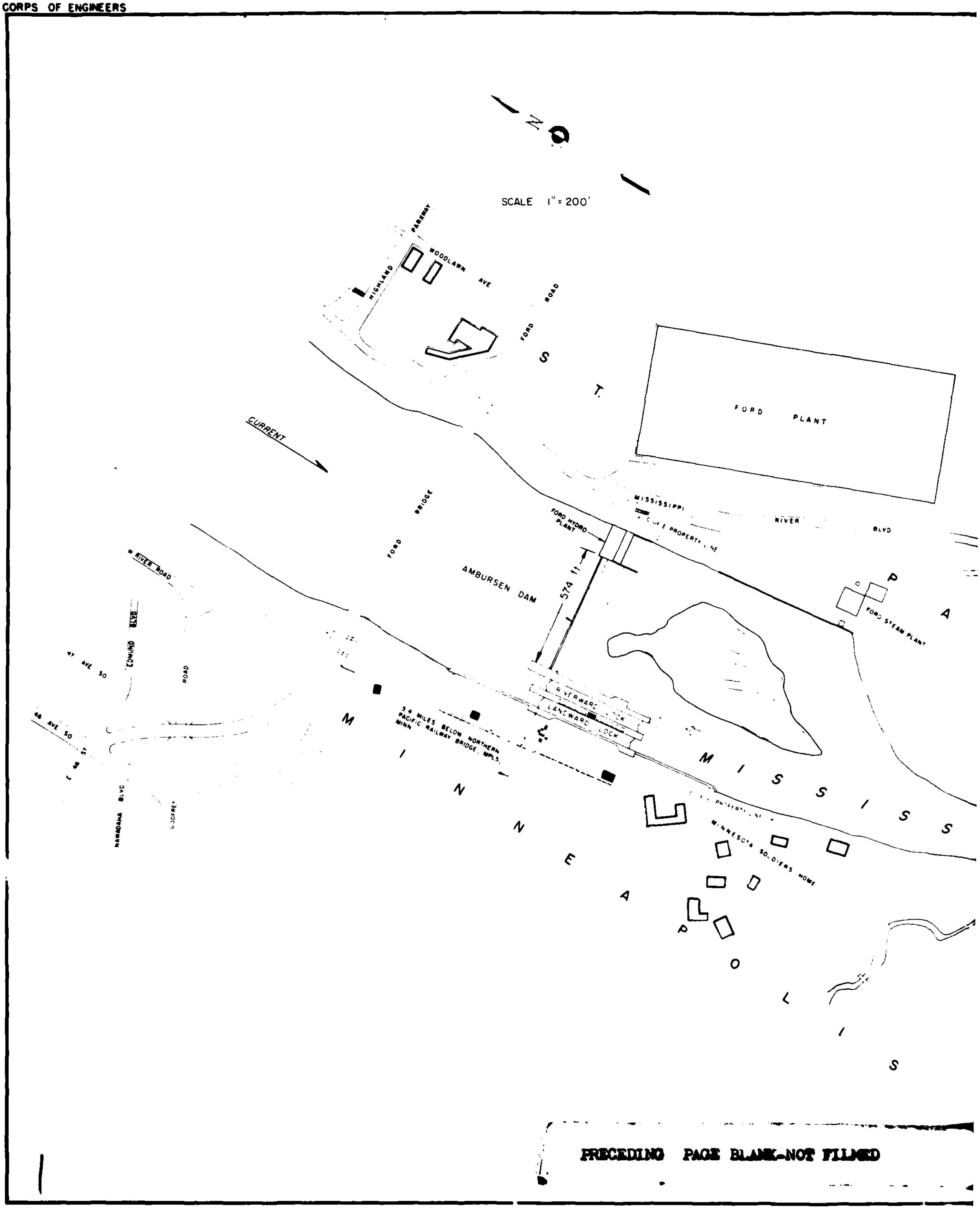
DATE

DRAWING NUMBER

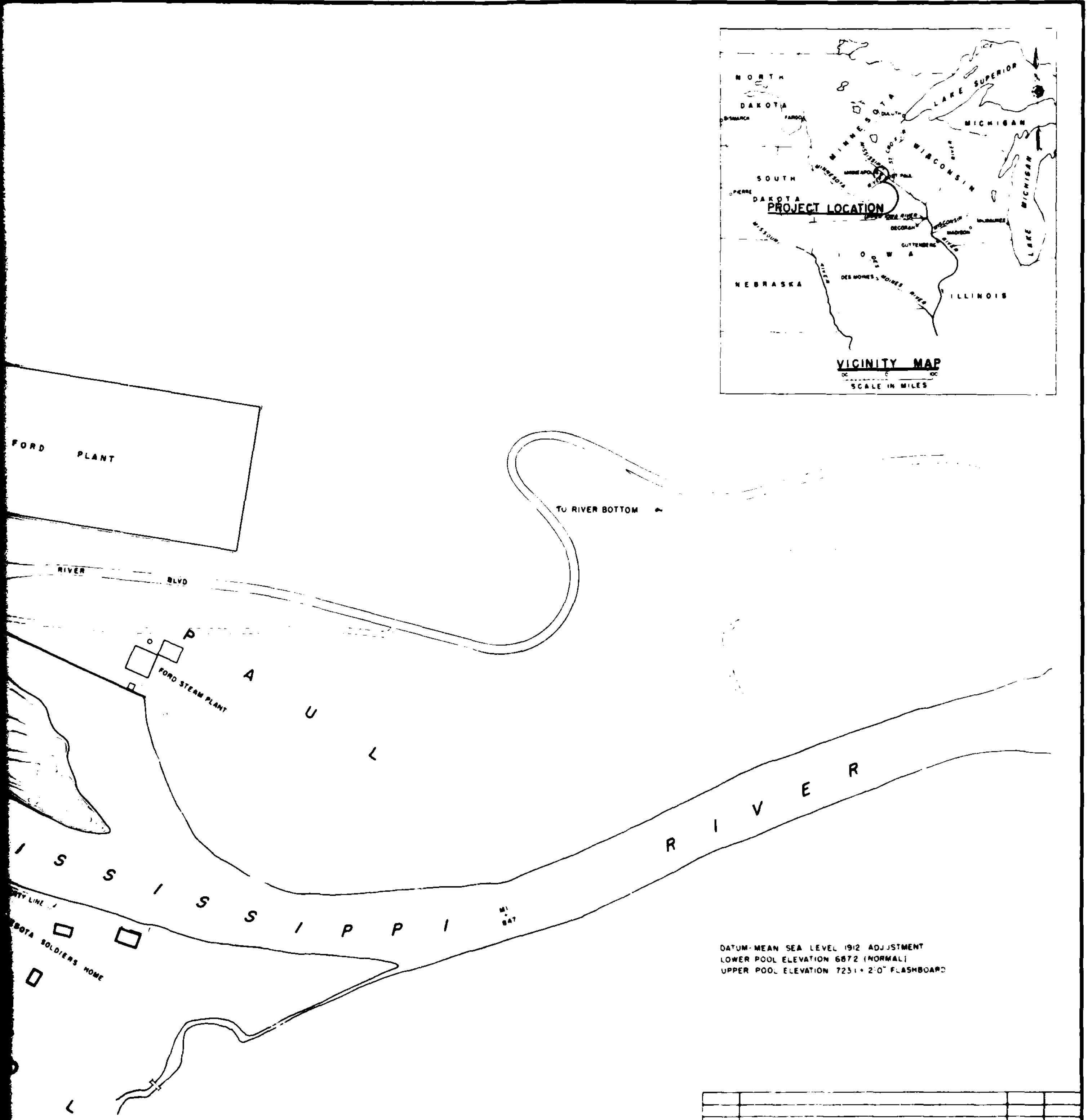
SHEET OF

PLATE 1

CORPS OF ENGINEERS



U.S. ARMY



DATUM-MEAN SEA LEVEL 1912 ADJUSTMENT
LOWER POOL ELEVATION 687.2 (NORMAL)
UPPER POOL ELEVATION 723.1 + 2.0' FLASHBOARD

SYMBOL	DESCRIPTION	DATE	APPROVAL

CORPS OF ENGINEERS, U.S. ARMY
OFFICE OF THE DISTRICT ENGINEER
ST PAUL, MINNESOTA

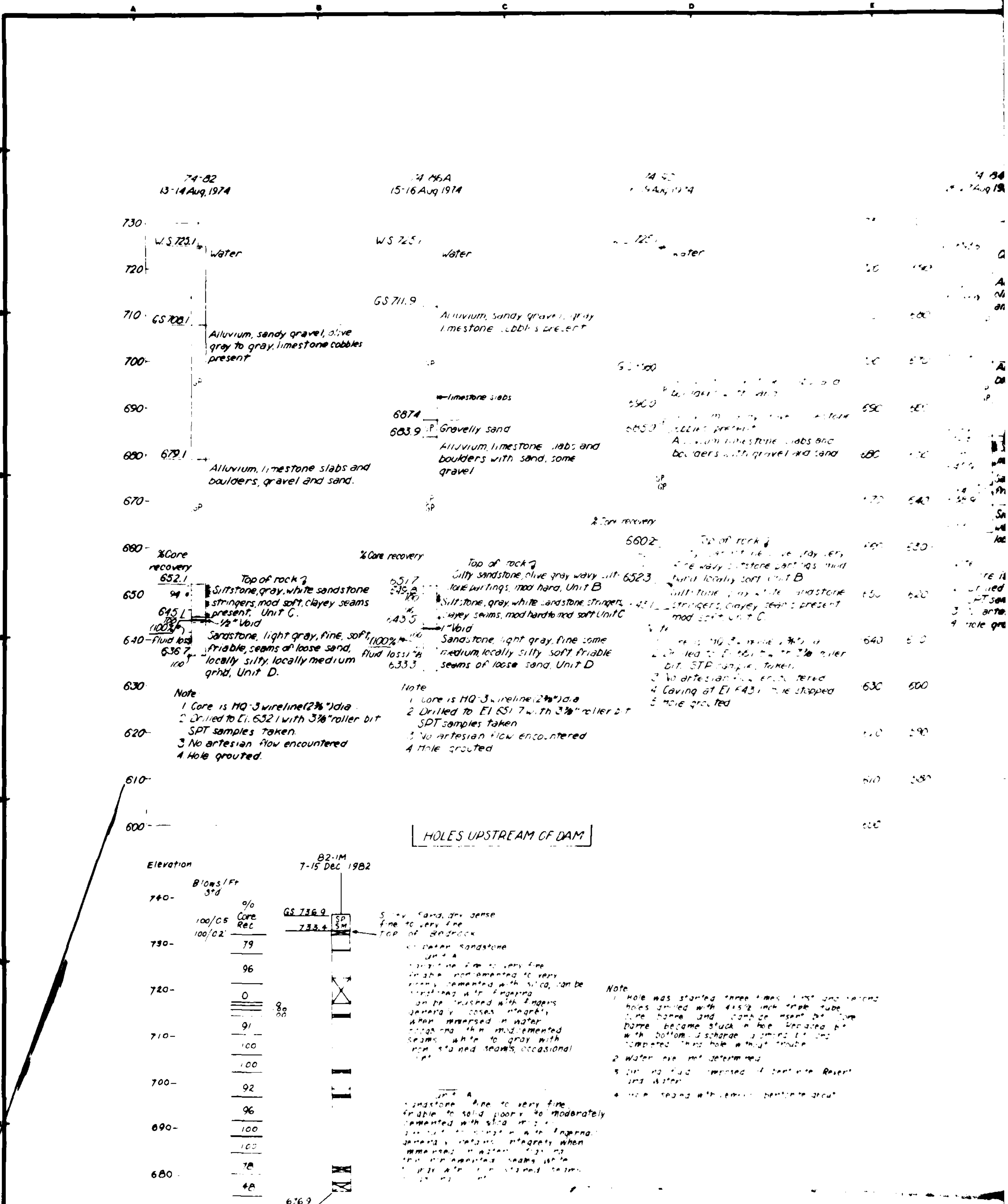
DRAWN BY
TRACED BY
CHECKED BY
SUBMITTED BY
CHIEF DESIGN BRANCH
APPROVED
CHIEF ENGINEERING DIVISION
APPROVED
CORPS OF ENGINEERS

MISSISSIPPI RIVER
LOCK AND DAM NO. 1
SITE MAP
HYDROPOWER FEASIBILITY STUDY

APPROVED
DATE
CHIEF TECH. ASST.
SCALE 1" = 200'
SPEC NO.
DRAWING NUMBER

PLATE 2

2



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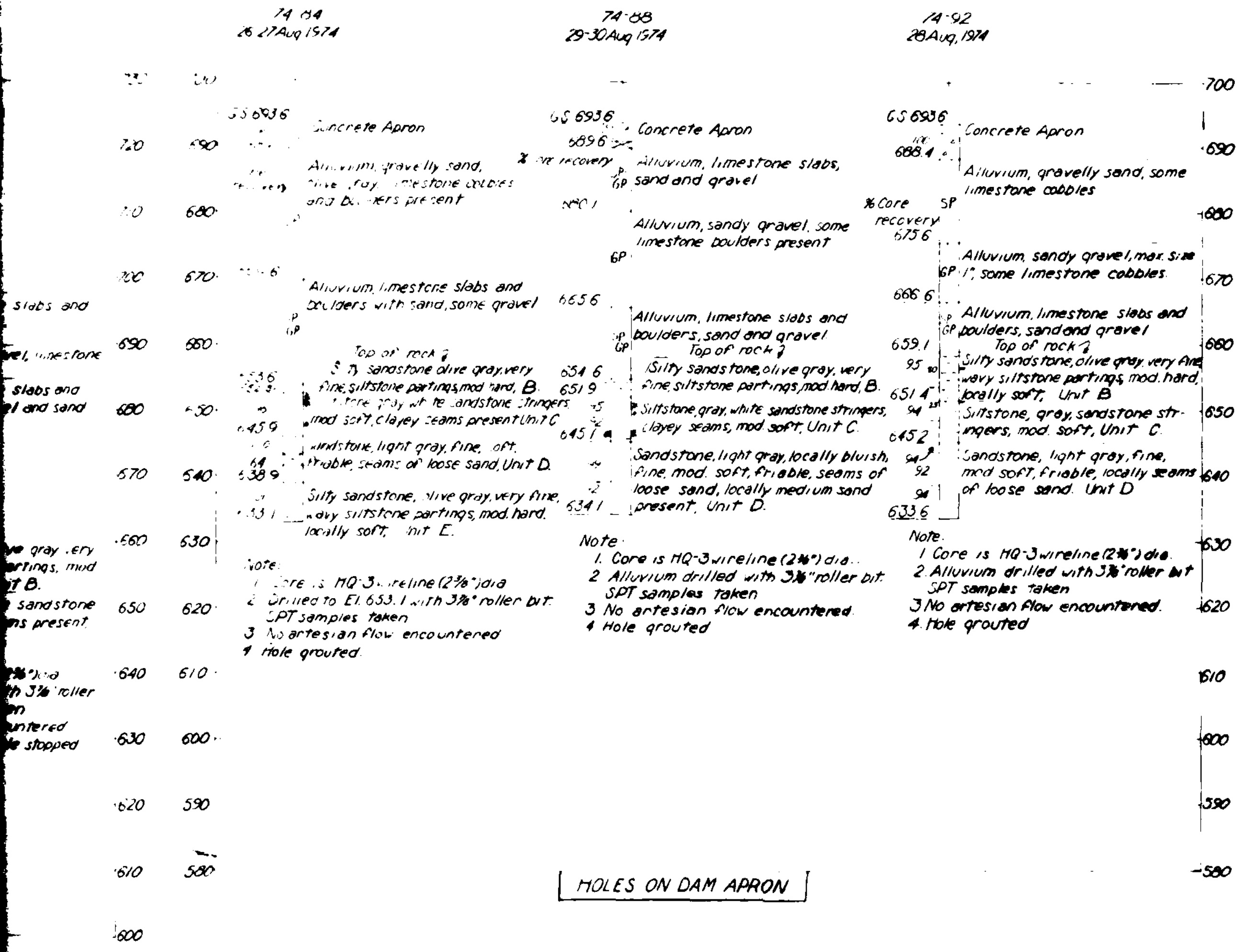


Note.
For boring locations see Plate 6

First and second triple-tube bit. Core replaced bit and double

Bentonite Revert

Bentonite grout

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

MISSISSIPPI RIVER
LOCK AND DAM NO. 1
BORING LOGS
HYDROPOWER FEASIBILITY STUDY

SUBMITTED BY:
APPROVED:
DATE:
SCALE AS SHOWN

SAFETY PAYS

PLATE 2

SCALE IN FEET

PHOTOGRAPH TAKEN 17 NOV 1979
BY
OWEN AYRES & ASSOCIATES, INC
MADISON, WISCONSIN

SUBMITTED BY

APPROVED

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT CORPS OF ENGINEERS
ST PAUL MINNESOTA

MISSISSIPPI RIVER

LOCK AND DAM NO 1

AERIAL VIEW

HYDROPOWER FEASIBILITY STUDY

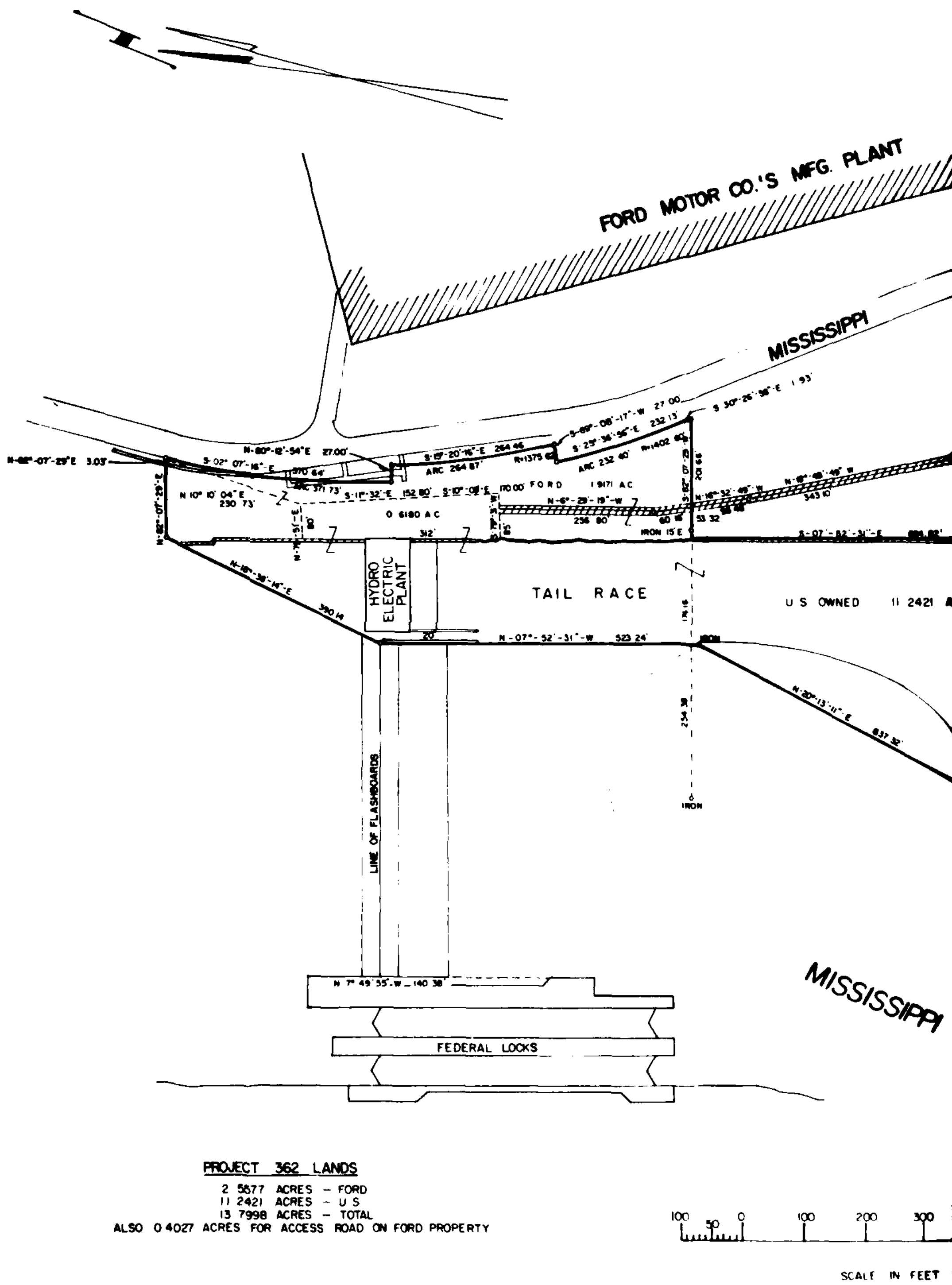
DATE

1" = 400'

DRAWING NUMBER

SHEET OF

PLATE 4



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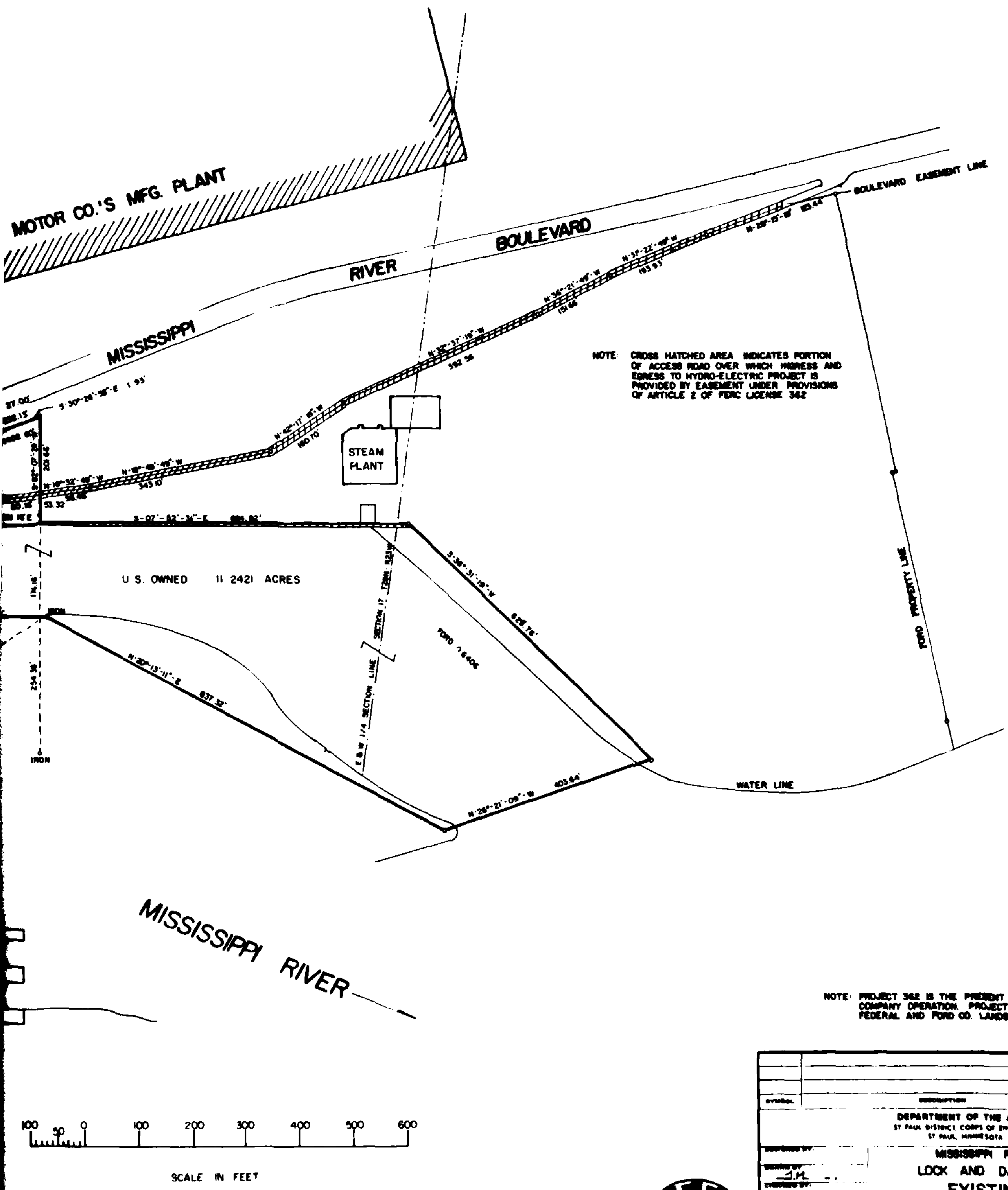


NOTE: PROJECT 362 IS THE PRESENT FORD MOTOR COMPANY OPERATION. PROJECT 362 INCLUDES FEDERAL AND FORD CO. LANDS.

DATA SOURCE: PROJECT 362 BOUNDARIES TAKEN FROM EXHIBIT 'K', SHEET 1 OF FORD MOTOR COMPANY LICENSE NO 362, DATED 30 DEC 1949 WITH THE FEDERAL ENERGY REGULATORY COMMISSI[illegible]N

SAFETY PAYS

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT CORPS OF ENGINEERS
ST PAUL, MINNESOTA

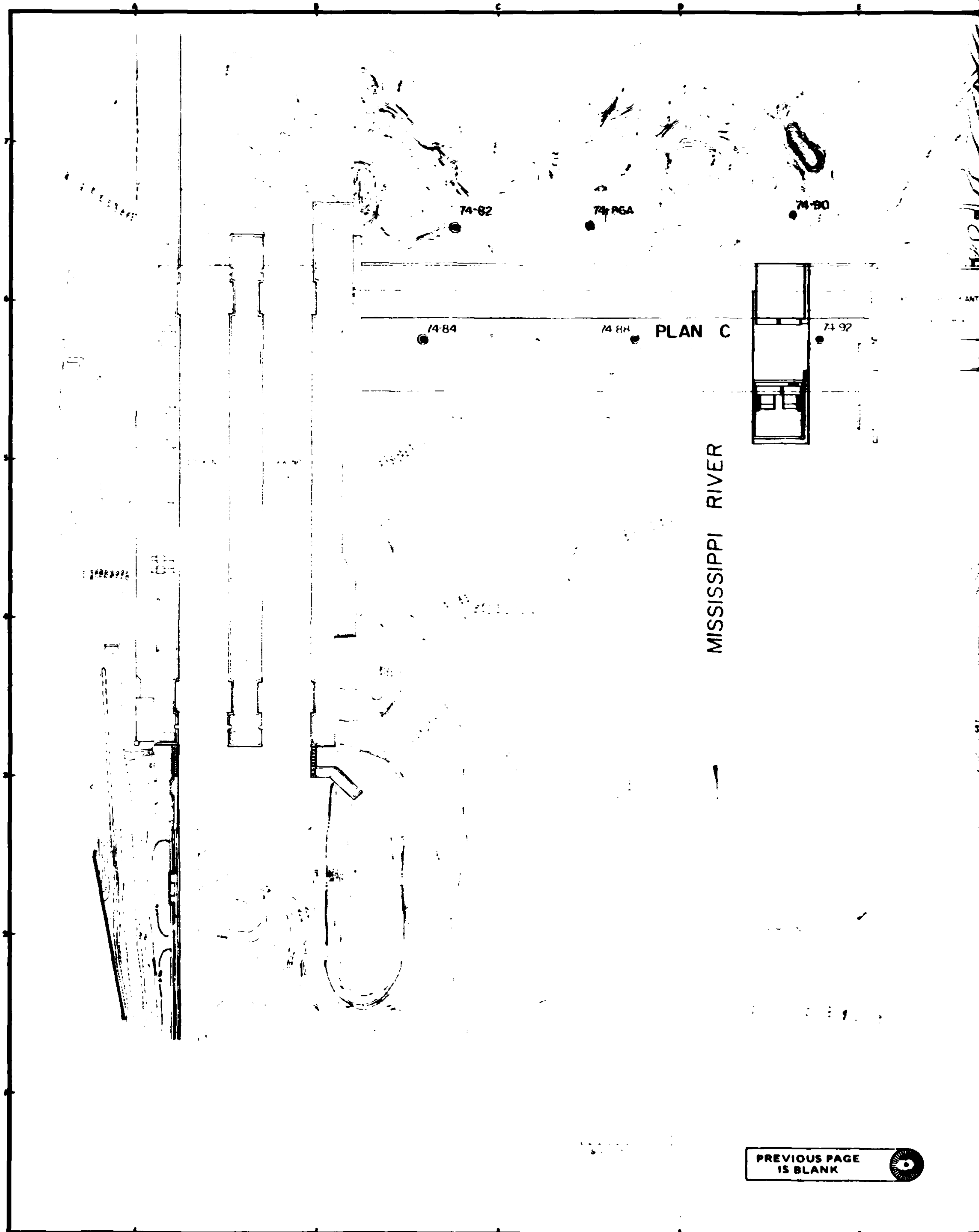
DESIGNED BY:
DRAWN BY: J.H.
CHECKED BY:
SUBMITTED BY
CHIEF BRANCH
APPROVED
CHIEF DIVISION

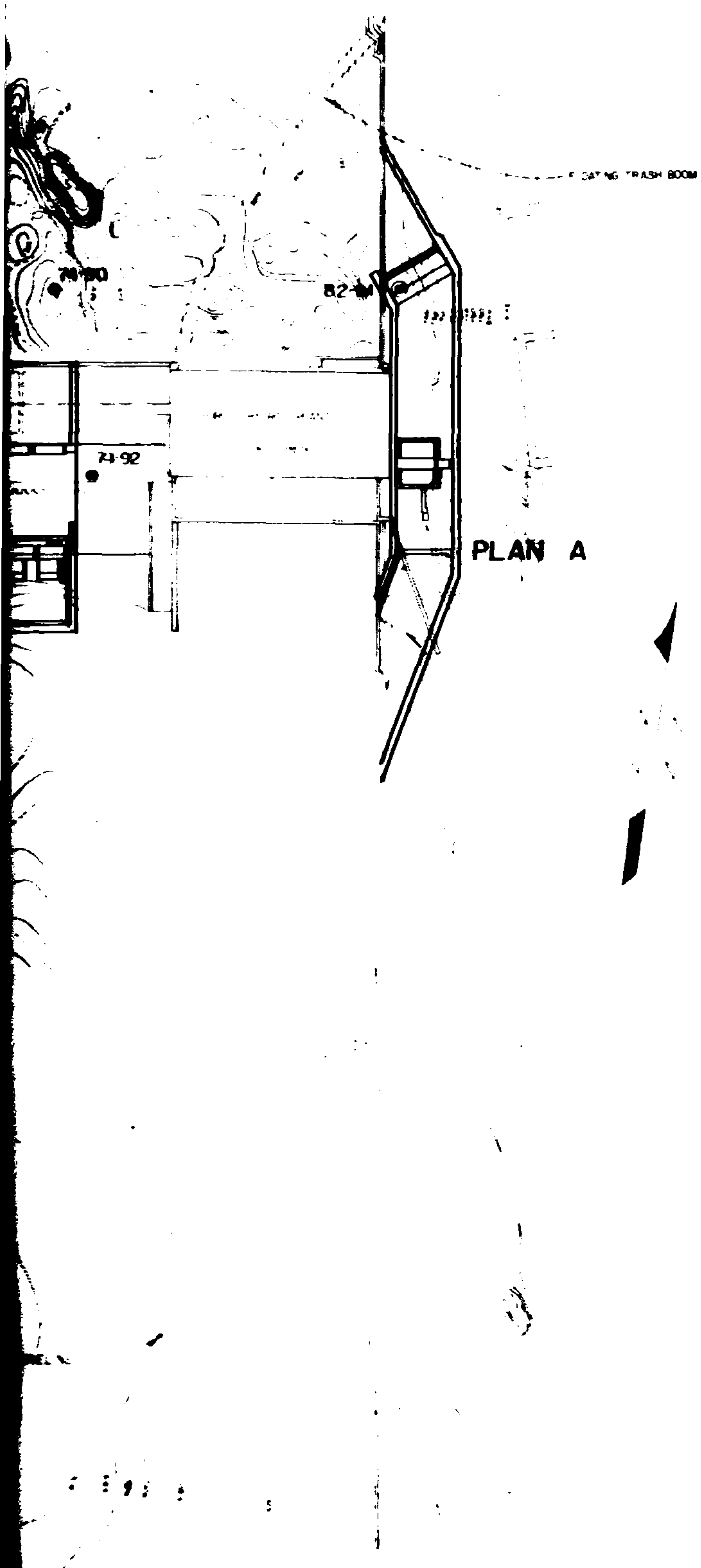
MISSISSIPPI RIVER
LOCK AND DAM NO 1
EXISTING PROJECT 362 BOUNDARIES
HYDROPOWER FEASIBILITY STUDY

DATE:
SCALE 1" 100'
DRAWING NUMBER
SHEET OF

2

PLATE 5

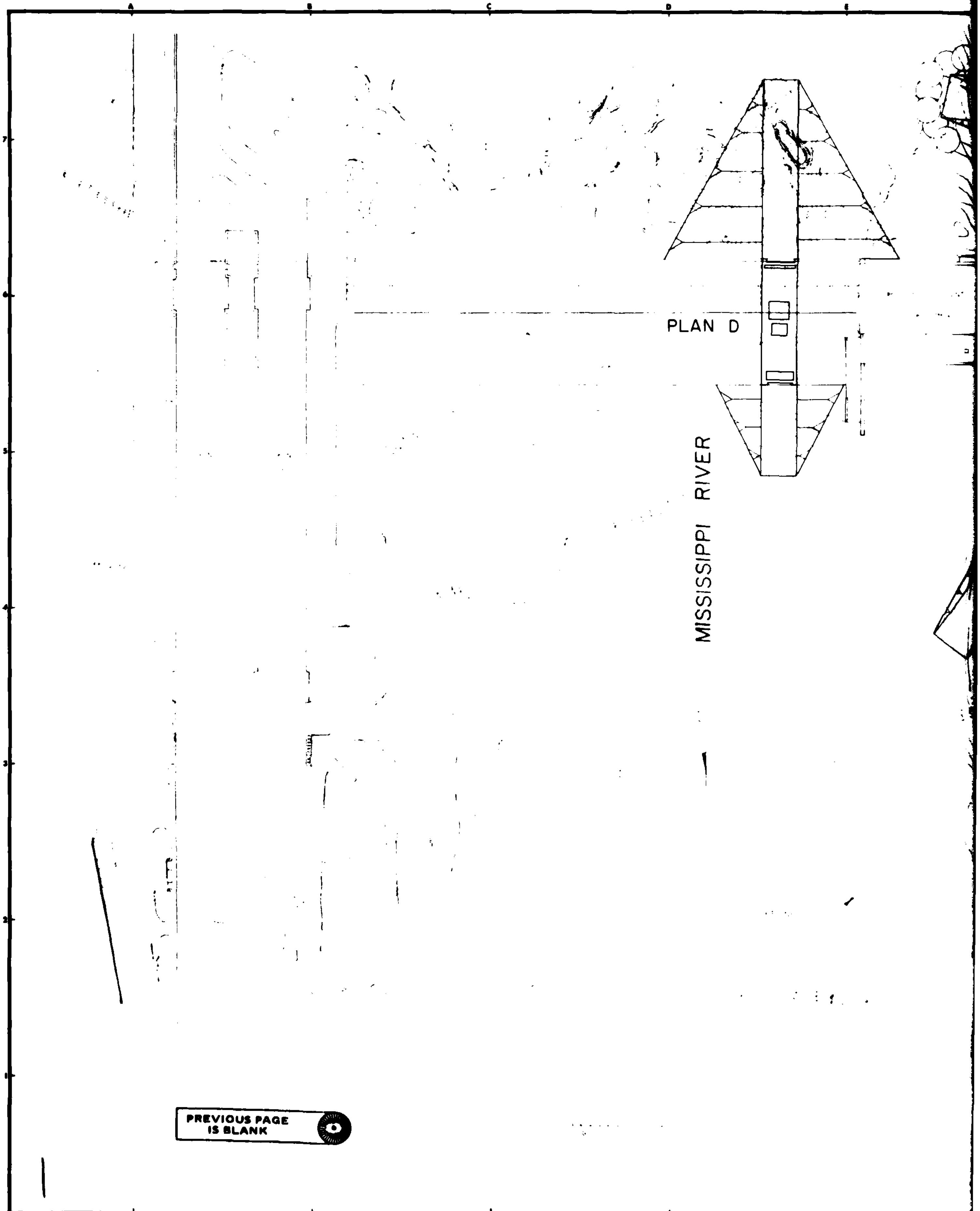

74-82
74-86A
74-90
74-84
74-88
PLAN C
74-92
MISSISSIPPI RIVER

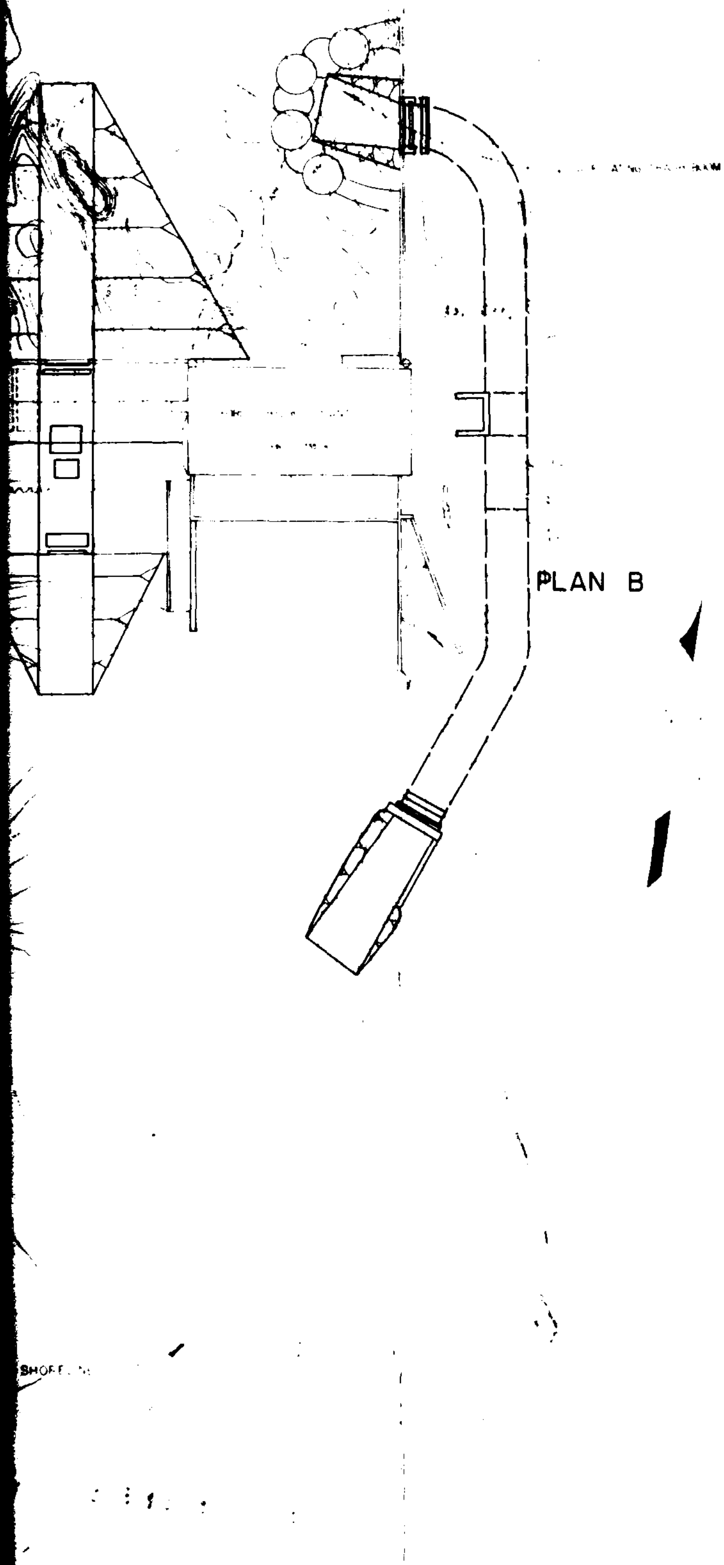


SUBMITTED BY:	LOCK AND DAM NO. 1
	PLANS A & C
	HYDROPOWER FEASIBILITY STUDY
APPROVED:	DATE: APRIL 1984
	1" = 50'
	SHEET OF

PLATE 6

2


PLAN D
MISSISSIPPI RIVER



SYMBOL	DESCRIPTION	DATE	APPROVAL

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ST PAUL DISTRICT, CORPS OF ENGINEERS
ST PAUL, MINNESOTA

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CHECKED BY:
SUBMITTED BY:
APPROVED:

MISSISSIPPI RIVER

LOCK AND DAM NO. 1

PLANS B & D

HYDROPOWER FEASIBILITY STUDY

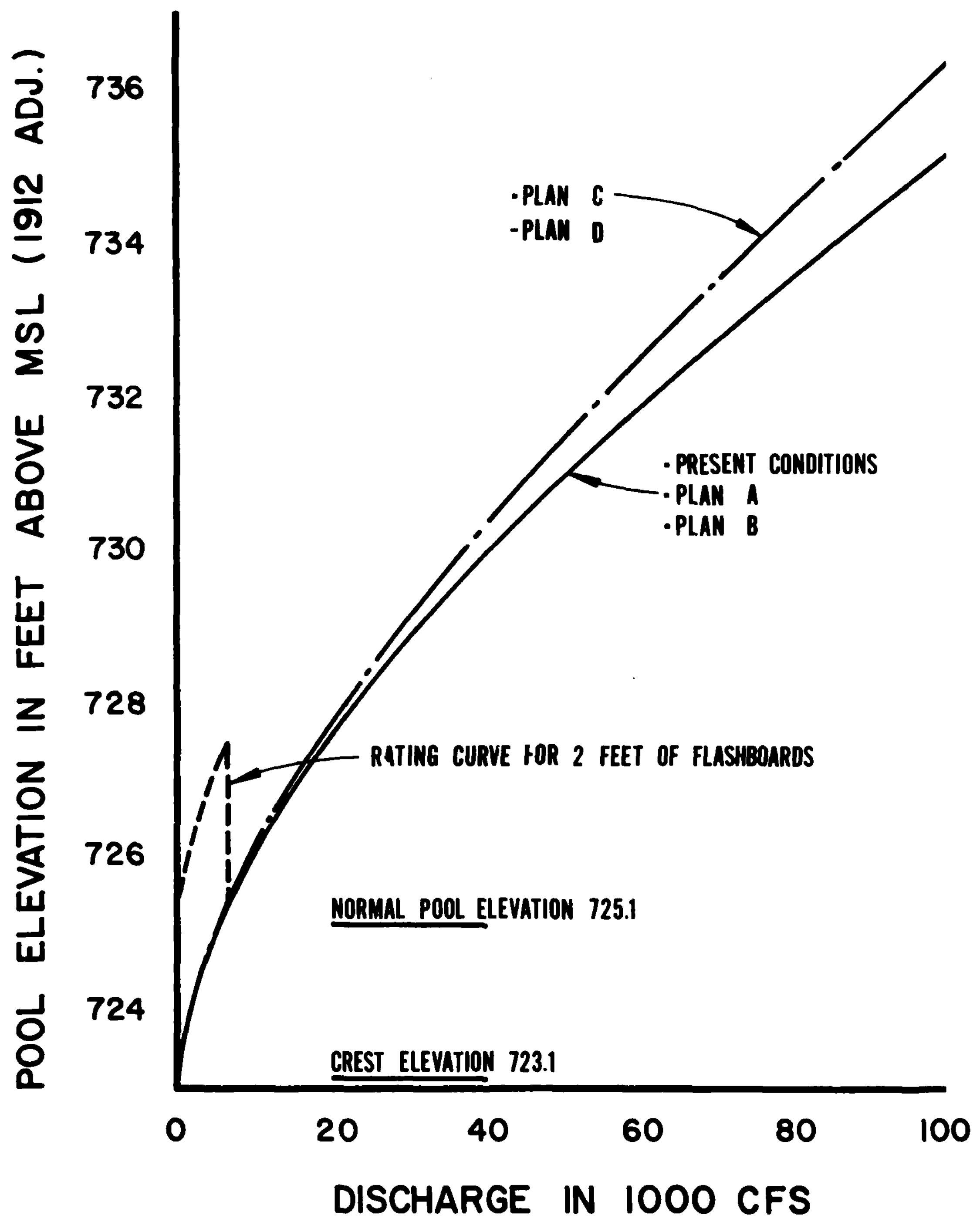
DATE: APRIL 1984

SCALE 1" = 50'

DRAWING NUMBER

SHEET OF

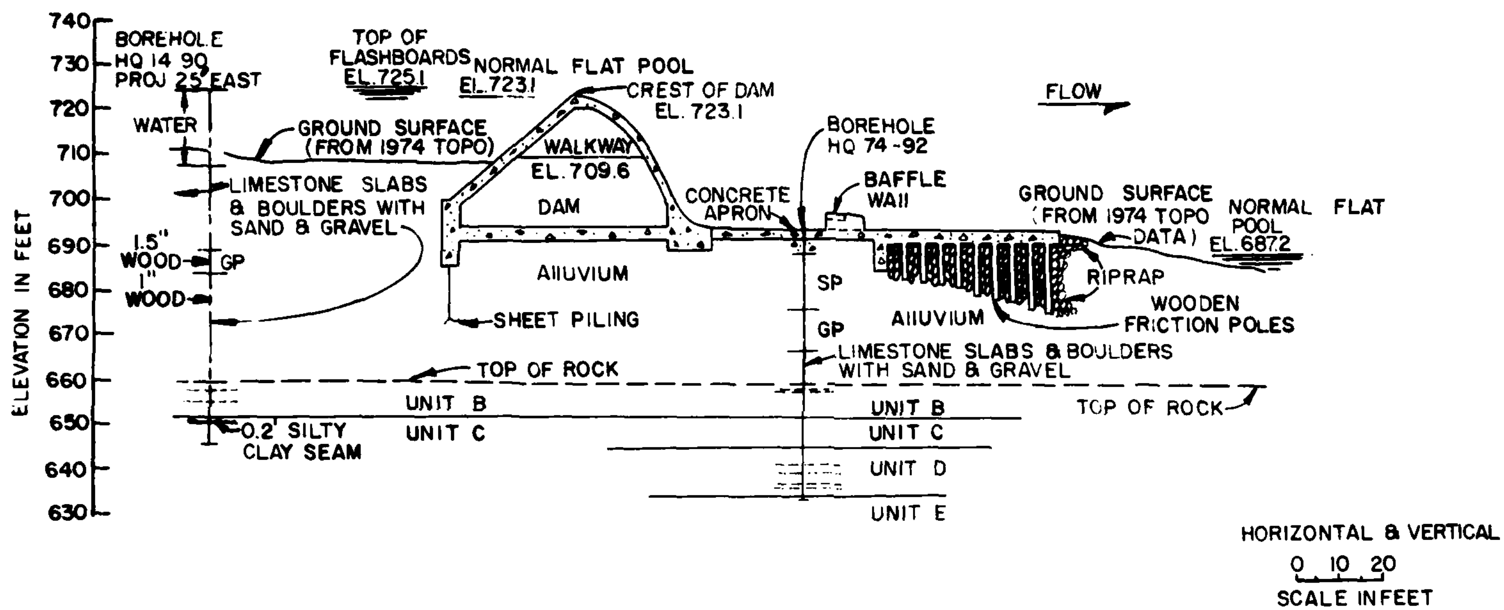
PLATE 7



MISSISSIPPI RIVER
LOCK AND DAM 1

CREST RATING CURVE

HYDROPOWER FEASIBILITY STUDY

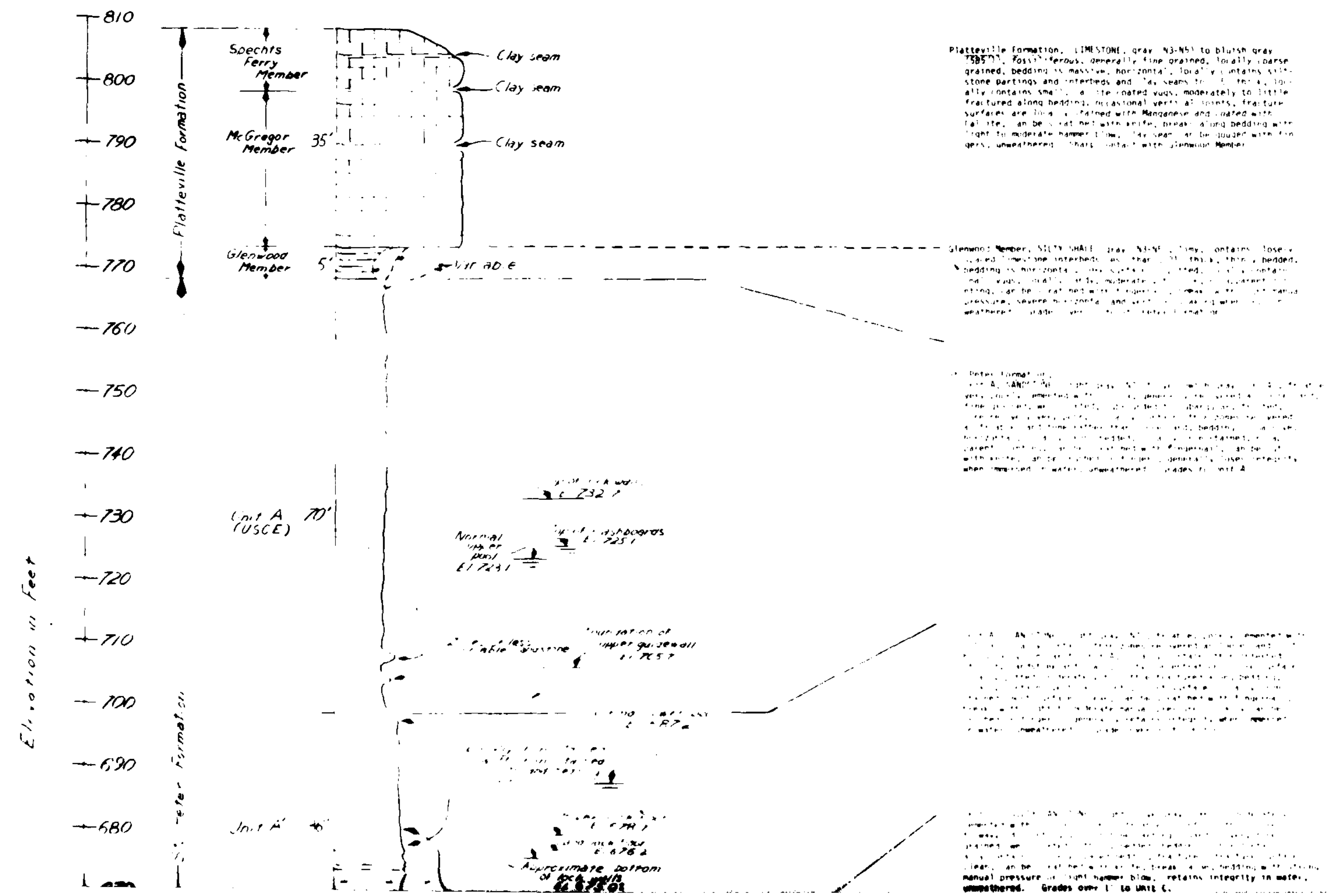


MISSISSIPPI RIVER LOCK & DAM NO. 1
GEOLOGY AND FOUNDATION EXPLORATION

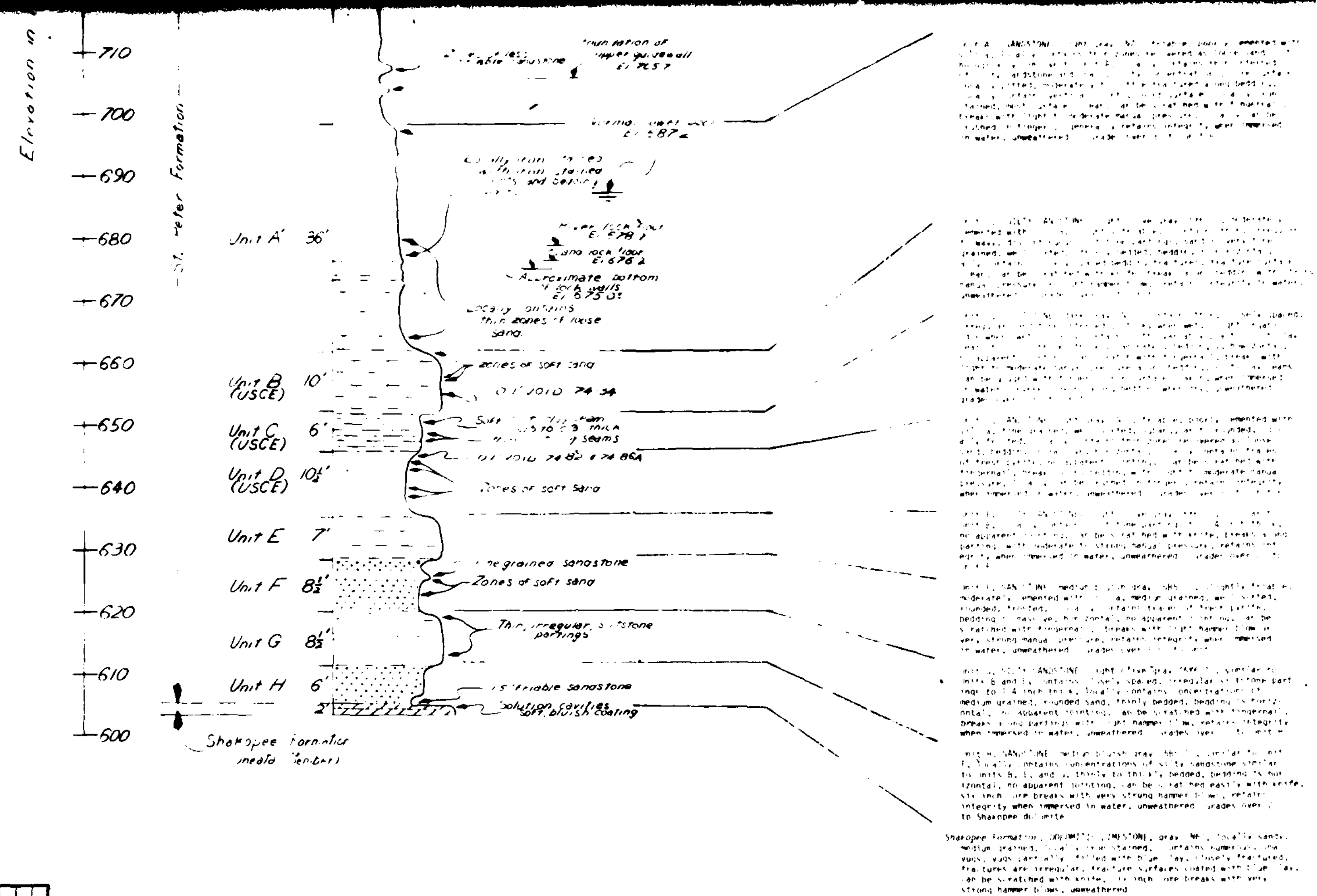
PLATE 9

Lock & Dam No. 1

Stratigraphic Column at Site



MASTER INDEX
LIFT DRAWING INDEX
MODIFICATION INDEX
MEMORANDUM INDEX
SHOP DRAWING INDEX



Notes:

1. Elevations are mean sea level (1912 adj.)
2. Lithologic units A, B, C and D defined by USCE; units A', E, F, G and H are defined in this study
3. Stratigraphic column is a compilation from 1979 drilling; refer to borehole logs for individual features
4. Colors are taken from the Rock Color Chart distributed by the Geological Society of America (1970).

REFERENCE DRAWINGS

MASTER INDEX - - - - - - - - - - - - - - - - - M-L1-0/3.7 & 0/3.7A
LIFT DRAWING INDEX - - - - - - - - - - - - - - M-L1-300/1 & 300/2
MODIFICATION INDEX - - - - - - - - - - - - - - M-L1-300/3 Thru 300/5
MEMORANDUM INDEX - - - - - - - - - - - - - - M-L1-300/10
SHOP DRAWING INDEX - - - - - - - - - - - - - - M-L1-300/15 Thru 300/22

SAFETY PAYS

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

MISSISSIPPI RIVER
LOCK AND DAM NO. 1
STRATIGRAPHIC COLUMN
HYDROPOWER FEASIBILITY STUDY

SUBMITTED BY
APPROVED
DATE
SCALE AS SHOWN
DRAWING NUMBER
SHEET OF

PLATE 10

FEASIBILITY REPORT FOR HYDROPOWER

LOCKS AND DAM 1

ST. PAUL-MINNEAPOLIS, MINNESOTA

APPENDIX

NORTH PACIFIC DIVISION TECHNICAL REPORT

US Army Corps
of Engineers
North Pacific Division

LOCK AND DAM NO. 1 HYDROPOWER STUDY

Mississippi River at Minneapolis-St. Paul, Minn.

PRELIMINARY
11 May 84

Technical Report • May 1983
Feasibility Level

HYDROPOWER STUDY AT
LOCK AND DAM #1 PROJECT
ST. PAUL, MINNESOTA

A Technical Report
for
Feasibility Study

Prepared for St. Paul District
Corps of Engineers as an
Element of their Feasibility Study

Hydroelectric Design Center
North Pacific Division
Corps of Engineers
Portland, Oregon

May 1984

LOCK AND DAM #1 PROJECT
ST. PAUL, MINNESOTA

BASIC PROJECT DATA

General Data

Normal Forebay Elevation	725.1
Minimum Forebay Elevation	724.0
Normal Minimum Tailwater	687.2
Spillway Crest Length	574 feet
Spillway Crest Elevation	723.1
Crest Elevation With Flashboards	725.1
Maximum Flood Flow (1965)	91,000 cfs
Median Flow	5,200 cfs
Minimum Flow (1976)	529 cfs

Proposed Powerhouse

Project Installed Capacity	7.2 MW
Number of Units	one
Type of Turbine	Tubular
Type of Generator	Synchronous
Runner Diameter	142 inches
Speed	144 rpm
Unit Centerline Elevation	682.00
Project Design Head	35 feet
Turbine Design Flow	1200 to 3050 cfs
Annual Plant Factor	34%
Average Annual Energy	21,450 MWh

Economic Data

Total NED Investment Cost	$11,607,000
Annual Cost	$1,035,000
Power Production Cost	48 mills/kwh
Annual Net Benefit	$116,000
B/C Ratio	1.11

SUMMARY

This report, prepared by North Pacific Division, Corps of Engineers, determines the feasibility of adding hydropower generation to the Lock and Dam Number 1 project, located on the Mississippi River in St. Paul, Minnesota.

The existing project consists of a concrete Ambursen-type spillway section, two navigation locks on the right side of the river and an existing 14.4 megawatt hydro plant on the left side. The Corps owns and operates the dam and locks, while the Ford Motor Company owns and operates the hydro plant.

This study shows that an additional powerplant can be built at the project, that will more fully utilize the existing river flows. Four alternative powerplant locations were investigated. The selected powerplant will be a 7.2 megawatt, single tubular unit, constructed at the spillway located near the existing powerplant. The new powerplant will produce 21.5 million Kwh of annual generation. The total investment cost will be 11.9 million dollars. The project is economically feasible with a benefit cost ratio of 1.11. The annual production cost will be 48 mills per Kwh.

The generation can be used in the existed power marketing area. Construction of this plant will preclude construction of an increment of thermal generation in the system.

HYDROPOWER STUDY
FEASIBILITY LEVEL

LOCK AND DAM #1 PROJECT

ST. PAUL, MINNESOTA

Table of Contents

SECTION 5 - PROJECT COST AND SCHEDULE

SECTION 6 - ECONOMIC

SECTION 7 - CONCLUSION

List of Figures, Plates and Tables

Appendices

SECTION 1 - GENERAL

1.01 Purpose and Authority. This report presents the results of an investigation into the economic feasibility of developing additional hydroelectric power at Lock and Dam Number 1 on the Mississippi River at St. Paul, Minnesota.

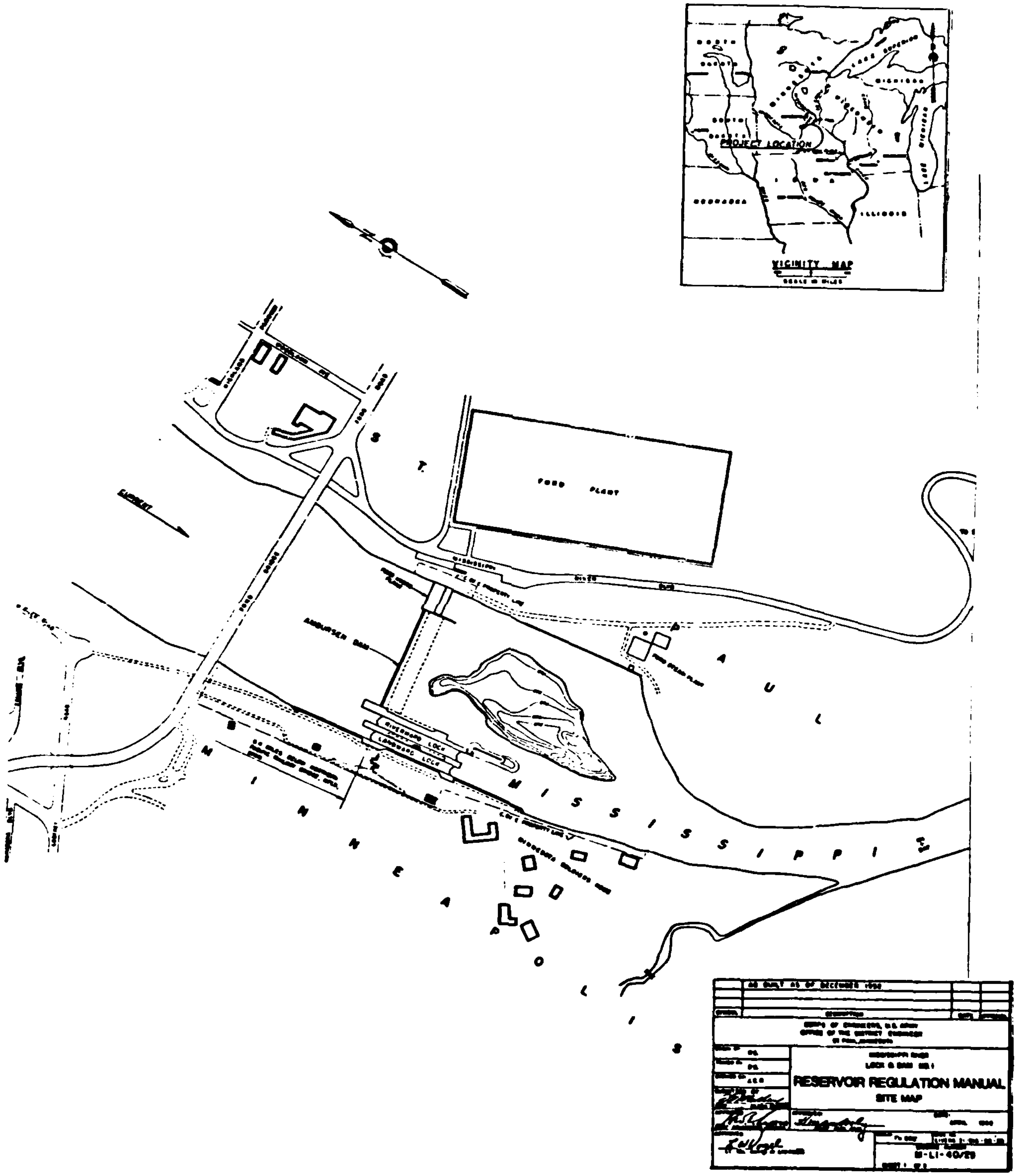
St. Paul District, Corps of Engineers, is conducting the study under authority contained in the House Committee on Public Works resolution dated 11 December 1969. Funds were made available by the District to the Corps' North Pacific Division for preparation of this feasibility level technical report on hydropower.

1.02 Scope of Study. Lock and Dam No. 1 is an existing inland navigation project located on the Upper Mississippi River between Minneapolis and St. Paul. This report assesses the potential of adding hydropower to the project. An existing powerplant at the site utilizes only a portion of the total available streamflows in the river. This study investigates the potential of constructing a second powerplant at the site that will develop flows beyond that now required to run the existing plant. Powerplant costs were developed from manufacturers' information for the turbine-generators and from current cost experiences for similar related equipment and structures. Using a series of annual costs and annual benefits, a net benefit analysis produced a selected plant size.

SECTION 2 - EXISTING FACILITIES

2.01 General. Lock and Dam #1 is located on the Mississippi River at mile 847.6 above the mouth of the Ohio River between the cities of St. Paul and Minneapolis, Minnesota (see Figure 2-1). The project consists of a 152 foot-long hydroplant adjacent to the left bank and a 574 foot-long crest-length Ambursen-type spillway dam, surmounted by 2 foot-high automatic release flashboards. The dam is equipped with eight sluiceways (only three sluiceways are operated and maintained at the present time) and twin 56 by 400 feet navigation locks. The hydroplant houses four Francis-type turbines having a total rated capacity of 14.4 MW. This powerplant was completed and placed in operation in 1924.

2.02 Project Operations. The existing powerplant is presently owned and operated by the Ford Motor Company under FERC Licence No. 362. The plant operates in a run-of-river mode because the primary purpose of the project is navigation. Under present conditions, the dam maintains a normal head of about 38 feet during the navigation season and about 36 feet during the winter season. The total rated hydraulic capacity of the existing units is 6670 cubic feet per second. The average annual energy production is 87.0 million KWH. About 40 percent of the project generation is consumed by the Ford Automative Plant and the Corps' operated locks. The FERC license specifies the existing terms of power supplied to the Corps of Engineer's lock operations. Power not used by the Ford Motor Company or the Corps is transmitted to Northern States Power Company.


VICINITY MAP
PROJECT LOCATION
FORD PLANT
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RIVERWARD LOCK
LANDWARD LOCK
AMBURSEN DAM
RESERVOIR REGULATION MANUAL
SITE MAP

Figure 2-1

SECTION 3 - HYDROLOGY AND POWER CAPABILITY

3.01 Hydrologic Analysis. The flow available for hydropower at Lock and Dam No. 1 was estimated from 50 years of data from the gage at Anoka, Minnesota (USGS 05-2885). The gage is 17.3 miles upstream of the project and there are no major tributaries between the two. The total drainage area adjustment was estimated to be 3.1 percent, based on the differences in areas and estimating the inflows and depletions in the Minneapolis, St. Paul area. This difference was accounted for in analyzing the average daily flow data through the project. There have been no major diversions or additions to the streamflow at the project and none are anticipated. For this reason the 50 years of historical data corrected for drainage area adjustment was considered appropriate for the estimation of the future operation of the powerplants.

3.02 Existing Power. Since the existing plant already utilizes part of the available streamflow, a basic assumption of this study was that any additional generation would come from flows in excess of the existing plant's hydraulic capacity. Thus, the new plant would operate only after the existing plant was operating at full capability. Close operating coordination between the existing plant and the new plant will be needed. This coordination will be especially important in the transition phase from low streamflows, when only the old plant will operate, to higher flows when both the old and the new plants will operate. This situation is discussed further in paragraph 2, Section 6.07.

The hydraulic capacity of the existing plant was derived from known generation output and actual daily flows. By simulating the existing

conditions, the hydraulic capacities were established after estimating several overall plant efficiencies. NPD's Power Duration Plot Program (described in Section 3.03) was used to estimate the energy output of the plant. These values are listed in Table 3-1.

TABLE 3-1

EXISTING PLANT DATA 1/

Annual Energy	Overally Efficiency	Annual Plant Factor	Plant Capacity	Hydraulic Capacity
87,000,000 kwh	81%	75%	13.2 MW	5400 cfs

The values listed above were calculated using average daily conditions. Certain values such as plant capacity and hydraulic capacity are slightly less than those published by the plant owner, the Ford Motor Company (described in Section 2). For example their published 14.4 MW of installed capacity and 6,670 cfs of hydraulic capacity is attainable only under the most favorable operating conditions. For this study the values shown in Table 3-1 were used and are considered more representative of the current operation.

Figure 3-1 shows graphically the annual flow-duration curve for the project. The existing plant flows are shown on the graph along with the plant flows of the selected plant (also see Section 6.07 for scoping). Once the hydraulic capacity was established for the existing plant, that flow was deducted from the daily streamflows in all successive analyses.

1/ Plant capacity and hydraulic capacity derived from other known conditions using NPD's DURAPLOT program.

3.03 Additional Power Potential. Several powerhouse sizes and alternative site locations were investigated. In addition, different types of generating units were studied. See Section 4.02 for more detailed descriptives of the alternative powerhouse site locations considered. Power development was initially investigated for four alternative powerhouse locations. Two of the alternatives were on the left side of the existing powerhouse and two alternatives were on the right side of the existing powerplant, within the spillway section. For all site investigations the generating heads and flows were the same; thus, the project benefits remained essentially the same, while the project costs varied with each alternative.

The power potential at each site was determined using NPD's Power Duration Plot Program (DURAPLOT). This computer program analyzes daily average flow, forebay and tailwater elevation data, and constraints associated with various sized power installations. For the flow and generating head ranges associated with specific turbine generator sizes, the program produces annual and monthly flow-duration curves and the corresponding power duration curves. Power is developed using the following equation:

$$\text{Average Power (kW)} = \frac{Q \times H \times e}{11.8}$$

where Q = average flow in cfs.
H = average net generating head in feet.
e = efficiency, assumed constant at 85% for bulb units and 84% for tubular units.

In this equation, daily project flows were computed by deducting flows equal to the existing plants' hydraulic capacity from the total flows as described earlier.

In applying the power equation forebay elevations were developed from daily historical data. The forebay elevations reflect the effect of flashboards, which are in place except during periods of high streamflow. Figure 3-2 shows the forebay rating curve used in this study. The tailwater elevation is affected by several conditions including the project flows and the downstream backwater effects. The backwater effects are a result of the general river configuration and the effect of the Minnesota River which has its confluence about 5 miles downstream from Lock and Dam No. 1. Recorded daily tailwater conditions vs the streamflow at the dam were analyzed. This data was then correlated with the Minnesota River flows near the confluence (see telephone log dated 21 December 1982 in Appendix D). An adjusted tailwater curve was developed from recorded data at the existing Ford hydro plant depicting total releases for both old and new plants. As discussed in Section 3.02, in all cases the existing plant was assumed to be operating at full capacity. This curve is shown in Figure 34. Net generating heads were determined by subtracting the daily tailwater elevations from the forebay elevations, then deducting an estimated head loss. A one-foot average head loss based on operating experiences with similar plants was assumed for all flow conditions. A head-duration curve was prepared and is shown in Figure 3-4. These curves were useful in establishing preliminary turbine operating limits for initial project scoping.

Table 3-2 summarizes the different generating plant sizes and their respective annual energy outputs and dependable capacities. This data was used to scope the project (see Section 6.07) and to determine the project benefits listed in Table 6-4.

Power duration curves were developed for all cases. An annual power duration curve for the selected plant (7.2 MW) is shown in Figures 3-5. Monthly flow-duration curves are shown in Appendix B and power-duration curves are shown in Appendix C. The shaded area under the curve represents the total flow or energy generation that can be developed with the selected plant size; the unshaded area represents the potential not feasible for development.

TABLE 3-2

SUMMARY OF PLANT SIZES AND GENERATION

(used for project scoping)

Hydraulic Capacity (cfs)	Installed Capacity (MW)	Annual Energy (MWh)	Annual Plant Factor	Jul-Aug Energy (MWh)	Hydrologic Availability 1/	Dependable Capacity (MW) 2/
1-Unit Tubular Plant						
1,650	3.9	13,110	38%	2,290	39%	1.5
2,200	5.1	16,600	37%	2,857	38%	1.9
3,050	7.2	21,450	34%	3,620	34%	2.4
2-Unit Tubular Plant						
2,725	6.3	19,440	35%	3,310	35%	2.2
3,500	8.5	23,430	33%	3,920	31%	2.6
4,400	10.0	27,540	31%	4,540	31%	3.1
6,000	13.4	33,360	29%	5,380	27%	3.6
3-Unit Tubular Plant						
4,545	10.2	27,970	31%	4,600	30%	3.1
5,500	12.3	31,620	29%	5,140	28%	3.5
6,500	14.4	34,890	28%	5,600	26%	3.8
7,360	16.0	36,910	27%	5,870	25%	3.9
1-Unit Bulb Plant						
3,500	8.4	24,210	33%	8,420	32%	2.7
5,900	14.0	34,710	28%	5,630	27%	3.8
6,790	16.0	37,820	27%	6,080	26%	4.1
7,650	18.0	40,500	26%	6,450	24%	4.3
9,300	21.7	44,970	24%	7,060	22%	4.7
10,400	24.1	47,500	23%	7,390	21%	5.0

1/ Based on the July-August energy divided by the achievable capacity for those months.

2/ (Installed Capacity) x (Hydrologic Availability)

3.04 Dependable Capacity. The dependable capacity of a hydropower project is usually defined as the amount of capacity available in a month or period of time that is considered most critical from the standpoint of both loads and hydrologic conditions. As such it is intended to reflect hydrologic availability. Dependable capacity is frequently less than installed capacity because the amount available when needed may be reduced because of low flows or reduced heads due to reservoir drawdown or tailwater encroachment. Various techniques have been used to measure dependable capacity, but it is widely agreed that for large predominately thermal power systems, traditional procedures often understate the true value of dependable hydroelectric capacity to the system. Procedures have been recommended by IWR 1/ and these have been used in this report. For a small run-of-river hydro project operating in a large, predominantly thermal power system, hydrologic availability is simply the average plant factor during the period of peak power demand. Thus,

Dependable Capacity = Installed Capacity x Hydrologic Availability.

The power system in which the Lock and Dam No. 1 project operates in, experiences both a winter and a summer peak load period. The summer load for July and August was used for establishing peak load in this study. Also see Section 6.09 which compares summertime and wintertime peak load periods. In Section 6, the capacity benefit is determined using the above definition of dependable capacity.

1/ US Water Resources Council, Water and Energy Task Force, Evaluating Hydropower Benefits, December 1981. Section 6.1.

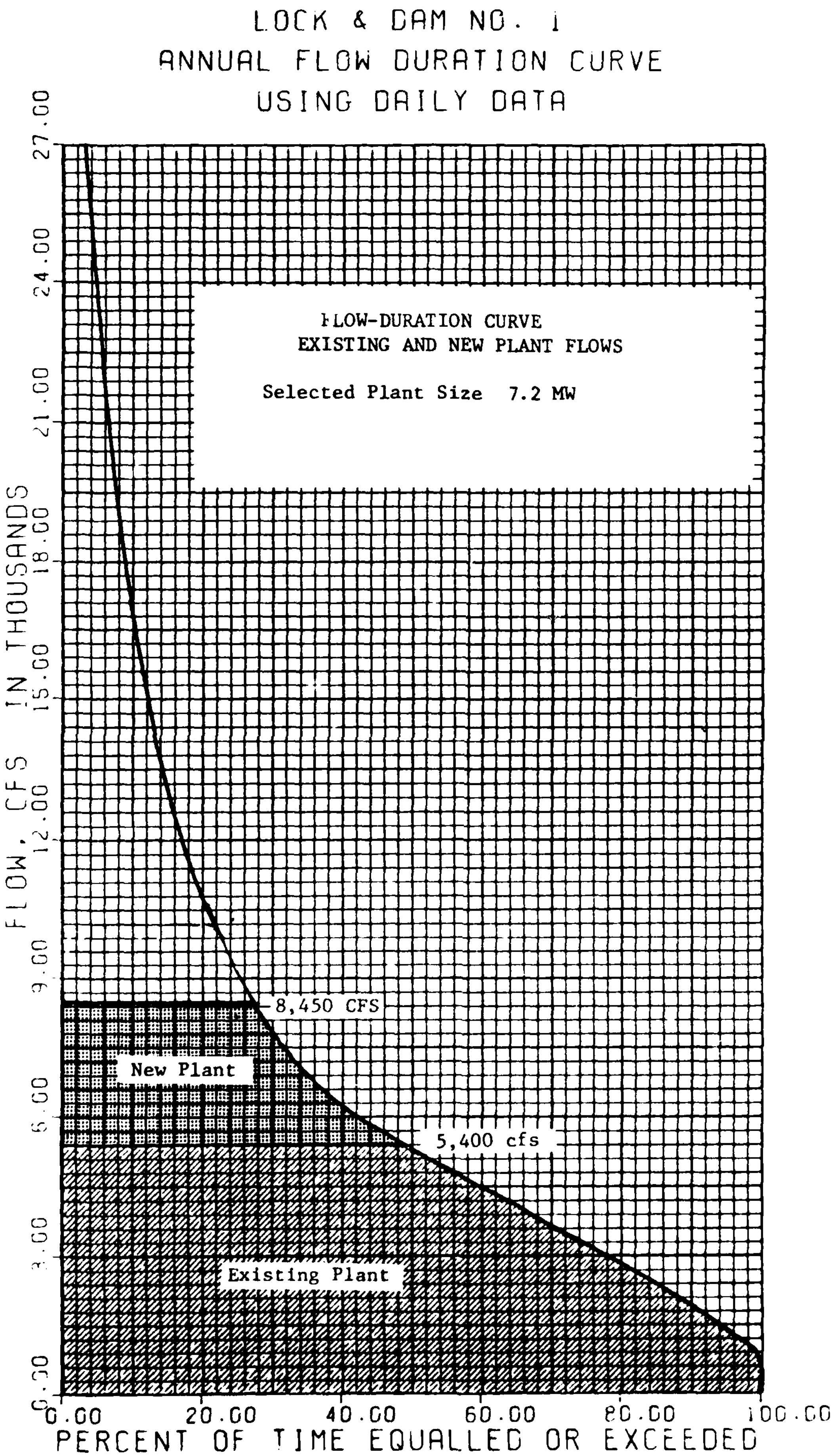

LOCK & DAM NO. 1
ANNUAL FLOW DURATION CURVE
USING DAILY DATA
FLOW-DURATION CURVE
EXISTING AND NEW PLANT FLOWS
Selected Plant Size 7.2 MW
8,450 CFS
New Plant
5,400 cfs
Existing Plant
FLOW, CFS IN THOUSANDS
0.00
3.00
6.00
9.00
12.00
15.00
18.00
21.00
24.00
27.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED

Figure 3-1

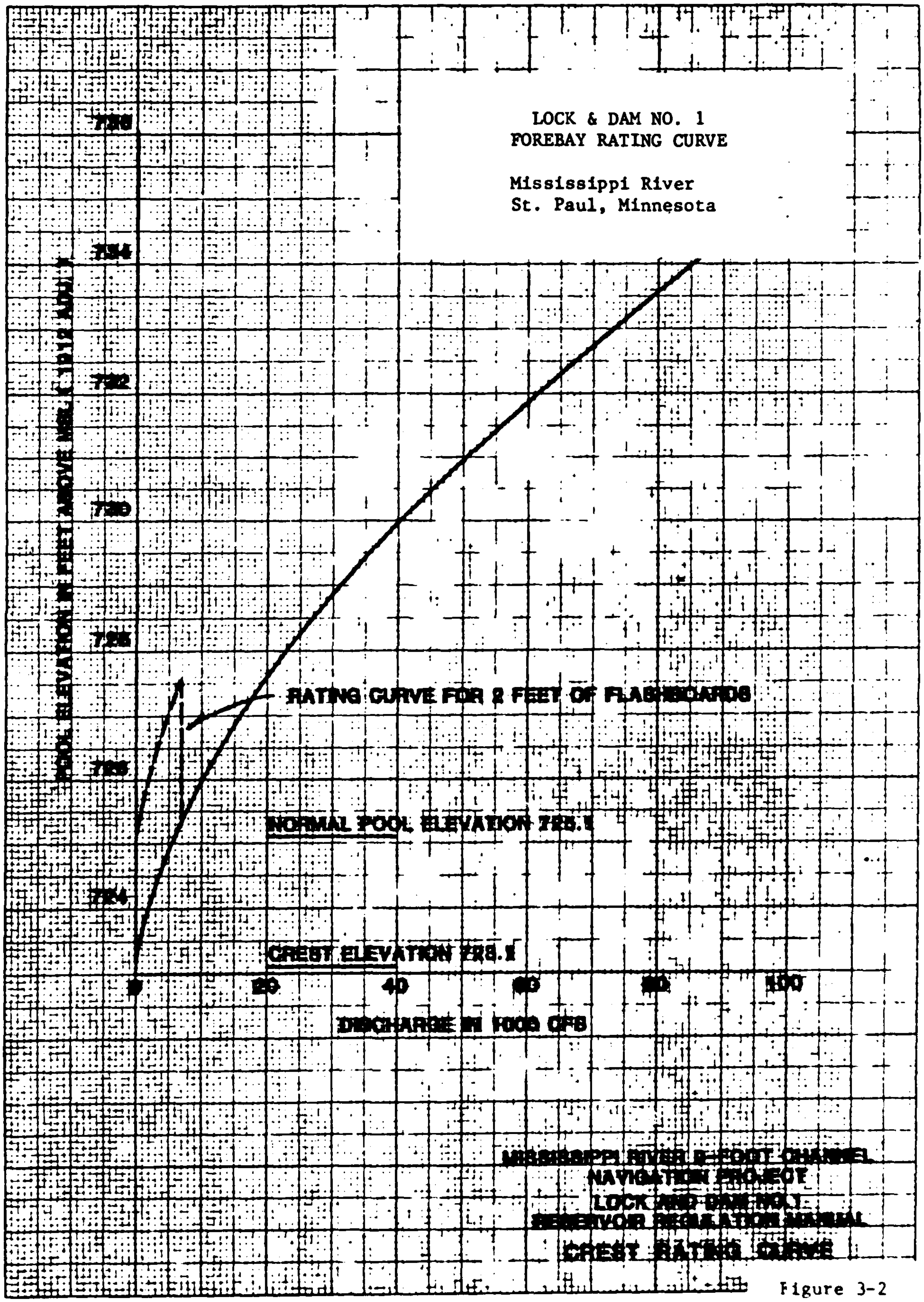

LOCK & DAM NO. 1
FOREBAY RATING CURVE
Mississippi River
St. Paul, Minnesota
RATING CURVE FOR 2 FEET OF FLASHBOARDS
0
20
40
60
80
100
DISCHARGE IN 1000 CFS
MISSISSIPPI RIVER 9-FOOT CHANNEL
NAVIGATION PROJECT
LOCK AND DAM NO.1
RESERVOIR REGULATION MANUAL
CREST RATING CURVE

Figure 3-2

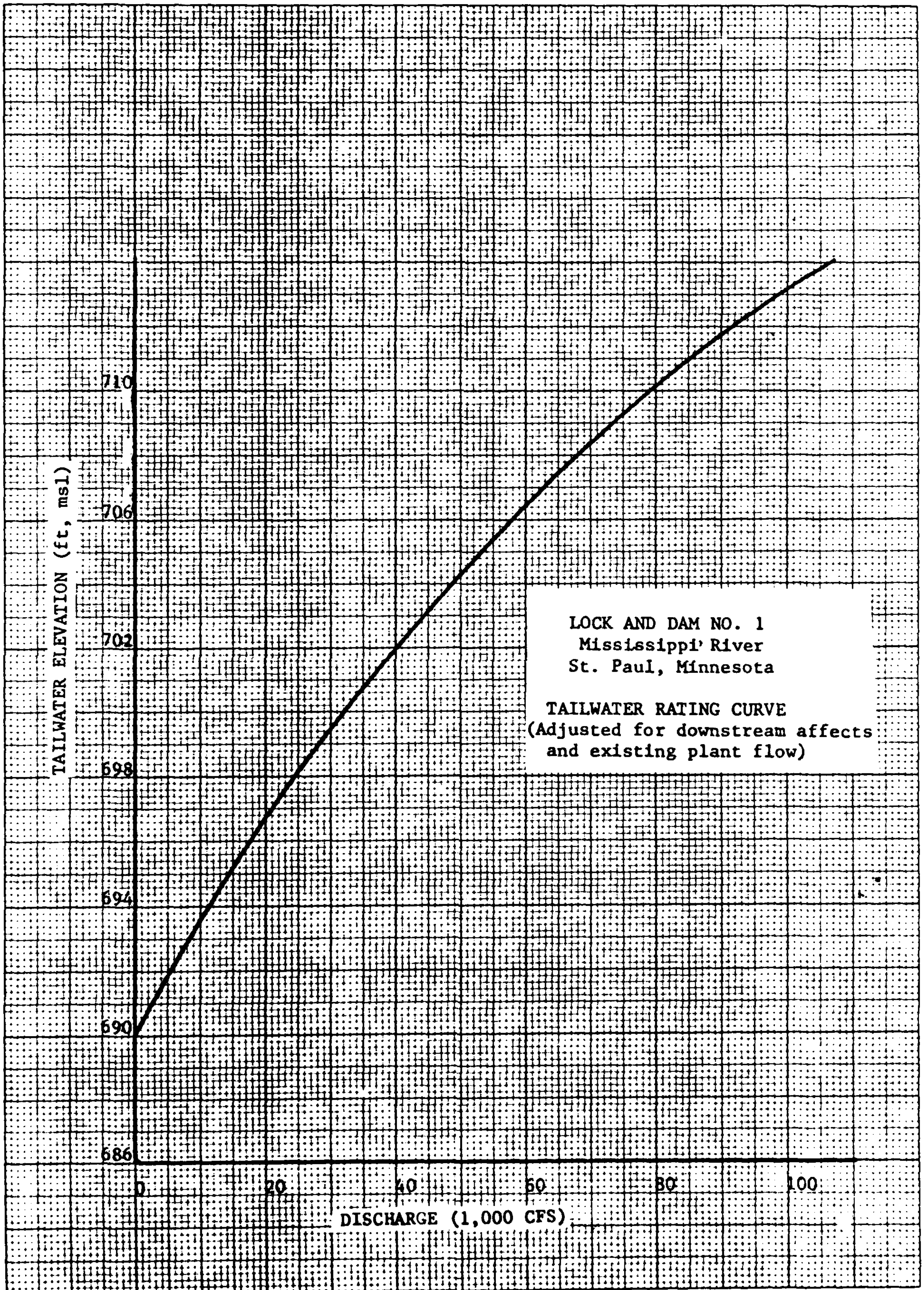
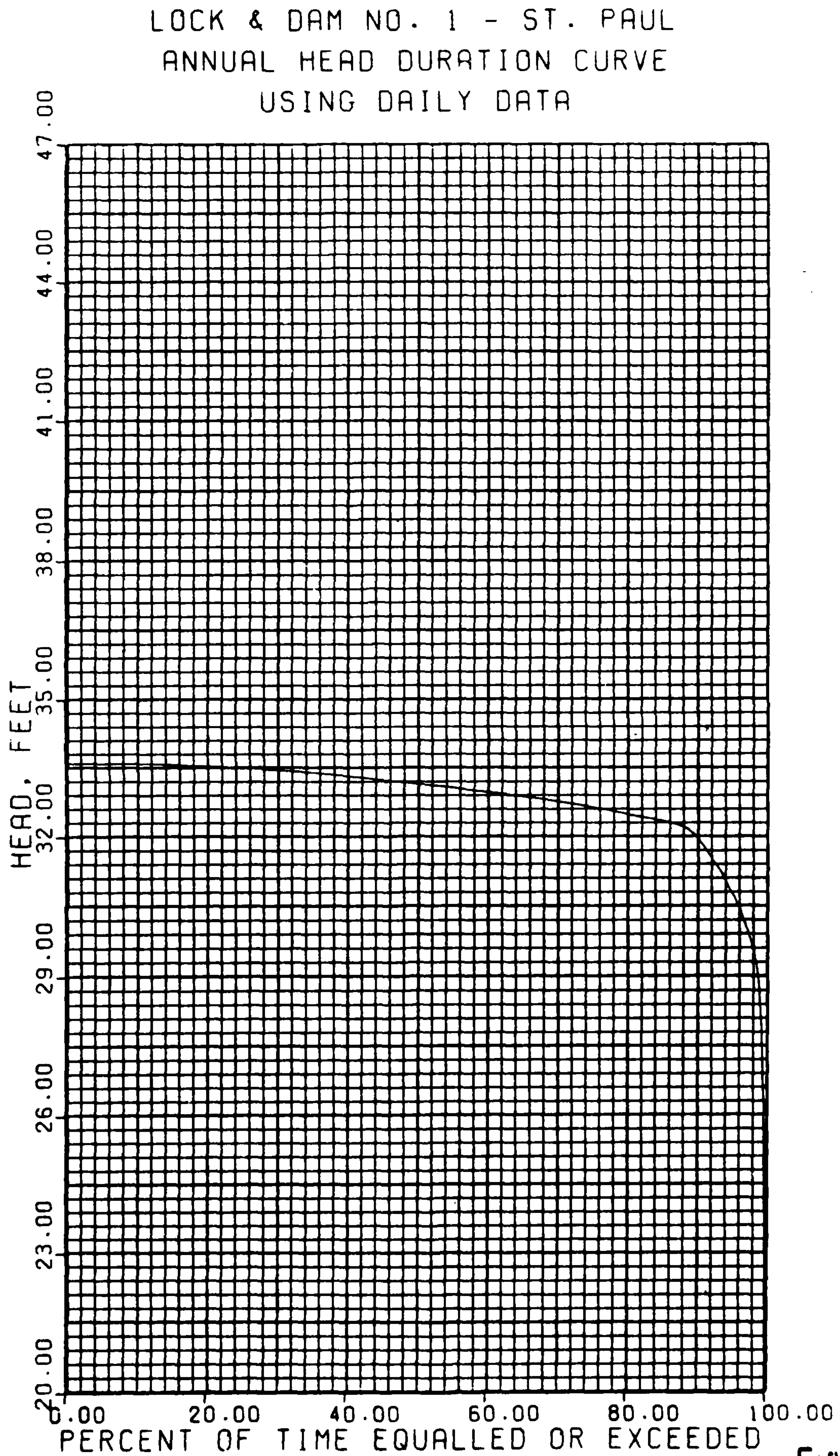

LOCK AND DAM NO. 1
Mississippi River
St. Paul, Minnesota
TAILWATER RATING CURVE
(Adjusted for downstream affects
and existing plant flow)
TAILWATER ELEVATION (ft, msl)
710
706
702
698
694
690
686
0
20
40
60
80
100
DISCHARGE (1,000 CFS)

Figure 3-3



LOCK & DAM NO. 1 - ST. PAUL
ANNUAL HEAD DURATION CURVE
USING DAILY DATA
HEAD, FEET
47.00
44.00
41.00
38.00
35.00
32.00
29.00
26.00
23.00
20.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED

Figure 3-.

LOCK & DAM NO. 1 - ST. PAUL
ANNUAL POWER DURATION CURVE
USING DAILY DATA

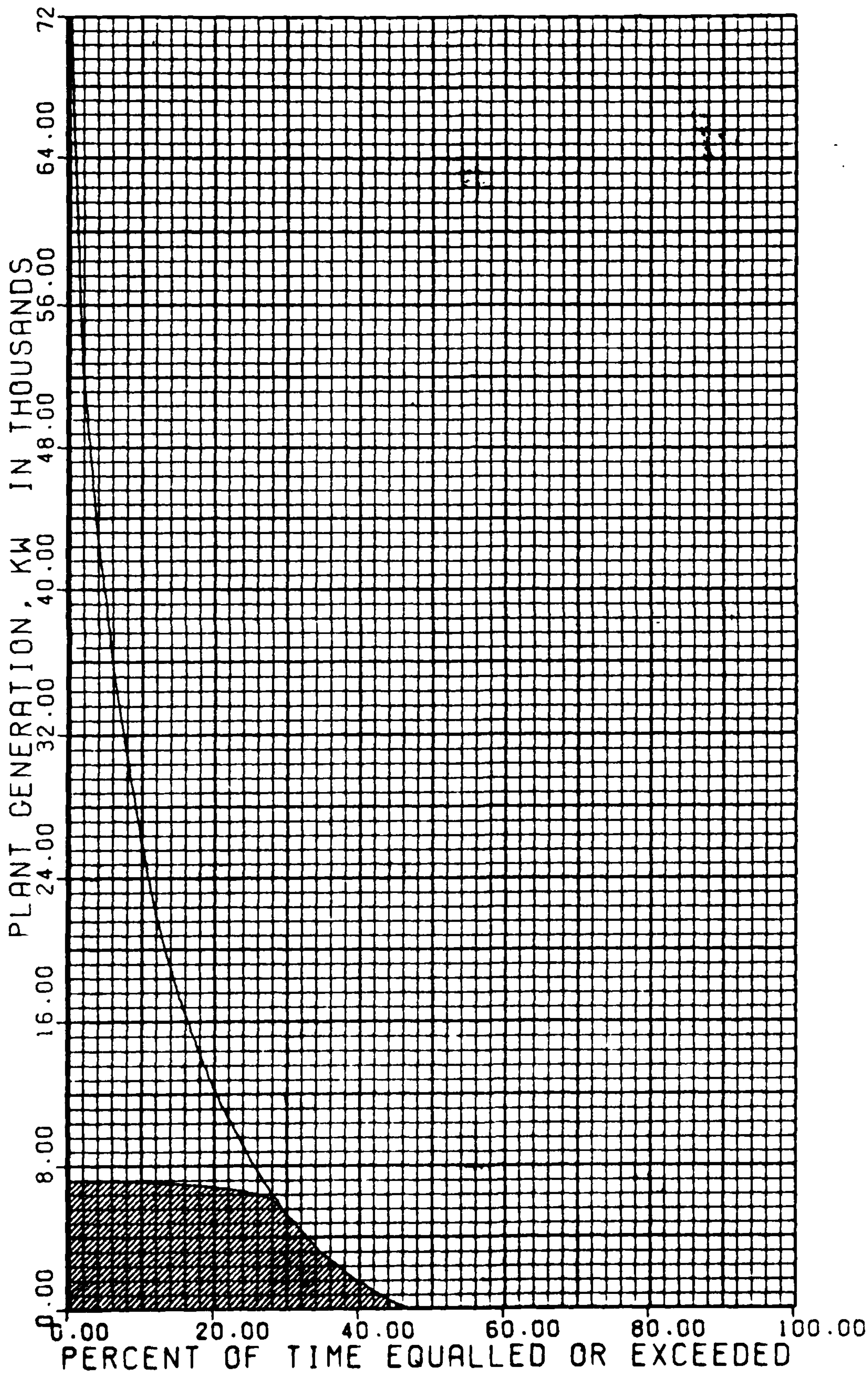


Figure 3-5

SECTION 4 - POWERHOUSE FEATURES

4.01 The proposed powerhouse is located at Site D, downstream of the existing spillway and 69' west from the existing Ford powerhouse. This allows the existing sluiceways to remain in operation after construction and does not interfere with the Ford plant during construction. The structure will be of reinforced concrete, housing a single 3600 mm tube turbine. The centerline of the runner will be set at elevation 682.0, or 5' below minimum tailwater. The upstream water intake is positioned at the toe of the spillway monolith, with the invert at El. 693.6. The intake water passage will descend to the turbine on a slope which can be excavated without danger of undermining the spillway foundation.

Sections of two spillway monoliths will be modified to admit water to the intake. The spillway face slab will be removed and one pier, providing a water passage approximately 29' wide. Fill concrete will be placed to retain the existing river bed. The exposed piers of the remaining spillway will require structural investigation for lateral stability. A intake stoplog slot and trashrack will be provided within the intake structure.

Within the powerhouse, a 12.5' by 36' turbine pit having a floor elevation of 667 will contain an unwatering sump used to unwater the waterway. The wicket gate assembly, servomotors, and counterweight along with other miscellaneous mechanical equipment will be located within the turbine pit. Located just downstream is a 20' x 30' control room and a 39' x 40' generator room at elevation 692 and 677.5, respectively. These rooms would contain the governor, switchgear, SCADA, excitation cubicle and appurtinent miscellaneous electrical equipment.

AD-A145 898 LOCKS AND DAM 1 (FORD DAM) MISSISSIPPI RIVER DRAFT FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT FOR HYDROPOWER(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT AUG 84 3B

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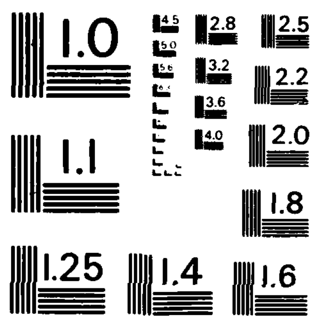

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

The main powerhouse, located at elevation 709.6, is attached to the existing Ford plants' tailrace deck by an access bridge. This bridge would facilitate operation personnel and minor maintenance. Access required for the initial installation and maintenanece of the major equipment would be by a barge accompanied by a barge mounted crane. A gantry crane will be provided and sized for all powerhouse lifts. As a secondary function, the gantry crane will be equipped with an auxiliary hoist, used for draft tube bulkhead installation and removal. An emergency gate is located in the tailrace water passage.

4.02 Powerhouse Site Locations Considered. In this study, four powerhouse site locations were reviewed to maximize power production and are described in the following paragraphs. Site D was recommended as the best location for the powerhouse, subject to future geotechnical investigation, and is referred to as the selected site in this study. All sites were studied using (a) single bulb unit (b) multiple standardize tubular units and (c) one 3600 mm standard tubular turbine. These are described as follows:

Site A. Site A is located adjacent to the existing Ford plant, on the east bank (see plate 3). At elevation 735 the bank is 40 feet wide bounded by a steep sandstone bluff reaching to elevation 800. The sandstone bedrock is exposed to the surface throughout the entire site. A steep narrow road used mainly for personnel and minor equipment replacement transverses the left downstream bank, directly adjacent to of the existing powerplant, terminating at the powerhouse at elevation 735. The large amount of open evacuation required at this site would make access difficult

to the existing plant.

A single horizontal bulb unit was selected for this site because of it's narrow width, thus fully utilizing all available space within the site. The additional width required for the larger capacity multiple tube unit plants eliminated them from the scope of this report. The base elevation of the foundation would slightly undermine the existing Ford plant, and may require special considerations during excavation. Due to the depth of the open excavation this plan will require further study by the District. Two sheet-pile cell-wall cofferdams were used for diversion and care of water at the upstream and downstream ends of the project. The placement of these cells would interrupt the operation of two existing generating units charging the project with a cost associated to the loss of poweer production. The upstream and downstream retaining walls will be removed after construction, as required, to complete a clear and smooth flowing channel.

A single 3600 mm tube turbine was placed at this site after the larger capacity plants was deemed infeasible. The powerplant was placed downstream of the existing Ford plant and access road. The intake would consist of a trashrack, intake gate and gate hoist placed perpendicular to the river flow by 200'. Water would then flow down a 16.5' x 16.5' reinforced concrete open channel. The last 100' would be covered with precast concrete covers to increase access flexibility. The draft tube would continue from the powerhouse discharging flow into the existing Ford plants' tailrace. Sheet pile cells were used for the upstream and downstream cofferdams. Future studys could allow the use sheet piles braced against the existing concrete wall eliminating the use of sheet pile

cells. This would lend to a savings in costs associated with the diversion and care of water and eliminate the cost associated to the loss of power generation at the existing Ford plant.

Site B. An underground powerhouse located within the sandstone bluff on the east bank was chosen as site B (see plate 4). In comparison with Site A, Site B would reduce construction related access restrictions to the existing Ford Plant. Preliminary investigations indicate that the tunnel excavation in this area is relatively inexpensive; therefore, this alternative is considered to be a viable solution.

This site was fitted with a single horizontal bulb unit fed by a single intake tunnel. A multiple unit plant was considered more expensive due to the additional width required deeming them less attractive. An intake portal equipped with a trashrack and an intake gate will be built behind the upstream retaining wall. This retaining wall will also act as a cofferdam in conjunction with a sheet pile cell wall and would be removed after the intake portal was completed. The cofferdams for Site B can placed so as to allow uniterrupted operation of the existing Ford plant. A 390 foot long lined tunnel with an access shaft extending to elevation 735, adjacent to the existing powerplant, will be used for a waterway and powerhouse access. The powerhouse will be located 80 feet east of the existing Ford plant and constructed entirely underground. The access shaft will be sized and equipped with cranes large enough to supply all required equipment to the underground powerhouse. The draft tube portal will be equipped with bulkheads, and will be located behind the downstream retaining wall. The retaining wall will be connected to the sheet pile cell wall, similar to the intake portal construction.

A single 3600 mm tube unit was choosen after the feasibility of the larger capacity plant proved negative. This powerplant was placed in the same location as the larger bulb unit utilizing the same intake and draft tube works. The waterway and powerhouse size requirements were reduced to facilitate the smaller tube unit.

Site C. Site C, is located adjacent to the existing powerplant along the west side (see plate 5). A precast Ambursen-type spillway dam along with a concrete apron, occupies this area both founded on timber piles. The dam is constructed of reinforced concrete slabs spanning an "A" shaped buttresses. This design would allow removal of the concrete slabs between two adjacent buttresses to make space for the intake structure. The powerhouse would be located on the dam apron just downstream of the intake structure. The orientation of the powerhouse could be skewed to minimize excavation requirements by making use of the existing trailrace. Sandstone bedrock is found at elevation 659 under a bed of alluvial fill consisting of sand and gravel. Eight 6 by 6 foot sluiceways are located in the spillway dam adjacent to the existing Ford plant; five of the sluiceways have been pluged. The three sluiceways closest to the existing powerplant are used to assist control of the pool during normal operation and would be removed to make space for the new powerhouse. This would require rejuvenating three of the pluged sluiceways to retain the same control of the pool during normal operation. Placement of the powerhouse at this site would reduce the capacity of the spillway by about 13%. This would increase the flood of record (1965) elevation by about one foot. There is little flood damageable property in pool 1 so that a one foot rise in flood elevation would have little consequence.

Three horizontal tube turbines were chosen for this site chiefly because the depth of excavation required is relatively shallower for these units. The depth of excavation associated with locating a bulb unit within the spillway would require extensive sheet piling and pressurizing grouting along the two adjacent sides to insure a stable foundation under the existing spillway and apron. This eliminated bulb units from this site. Access for large equipment during construction and for major repairs will be by crane mounted barge. Smaller equipment will be transported down the road along the east bank, across the Ford plant's tailrace deck and into the powerhouse. Unlike Sites A and B, this site would not be accessible during the greater flooding conditions. The dam does not provide sufficient head to allow Sites A and B to continue operating up to the largest of flooding conditions. The powerhouse was located slightly downstream from the dam in order to reduce the undermining of the existing Ford plant, thereby affecting it's stability. An upstream sheet pile cell cofferdam would tie into the spillway dam, reach across the front of the proposed powerhouse excavation and connect into the front of the existing Ford plant. The cofferdam would require that two of the existing four turbines be shut down for 18 months. The loss of existing power generation are reflected in the project economic evaluation. A downstream cofferdam would tie into the west downstream training wall, then extend across the new tailrace, and connect into the downstream lip of the spillway apron.

A single 3600 mm tube unit power plant was estimated at this site for purposes of comparing the costs with the other sites. This plant is similar to the three unit plant in arrangement and orientation. The diversion and care of water for the one unit plant is subject to the same

associated costs as the three unit plant.

__Site D.__ Site D is located within the spillway on the west side of the existing Ford plant, offset by 69 feet (see plate 2). This site is similar to Site C with the exception that there is no loss of existing generation power at the Ford plant during construction. The upstream and downstream cofferdams would tie into the spillway adjacent to the existing plant. The depth of excavation associated with a bulb unit at this site requires costly protective measures as discussed in alternative Site C. Access for personnell access and minor equipment maintenance would be provided primarily by a bridge connecting the two tailrace decks together. A secondary access required for heavy equipment would be provided by a barge accompanied by a barge mounted crane.

Three horizontal tube turbines were initally choosen at Site D over a bulb turbine due to the additonal cost of excavation as discussed in prior sections. Powerhouse configurations and layout is similar to the three unit powerplant as discussed in Site C.

After the larger capacity multiple tube unit plants proved infeasible, two and one unit plants were scoped at the sites within the spillway. This yielded a single 3600 mm tube turbine as being most feasible. For comparison purposes, cost estimates for this single tube unit powerplant were prepared for each site. For a more detailed description see Section 4.01.

4.03 __Turbines.__ For the purposes of this study, a single full Kaplan (adjustable blade with wicket gates) "standardized" tubular horizontal

shaft bulb turbine was studied for the selected powerhouse site. Initial investigations of the number and type of turbines (vertical, Kaplan, horizontal, bulb, "standardized" tubular) appropriate for this site indicated the greatest economic advantage for the turbine selected. The choice of a Kaplan tubular type turbine was based upon the relatively low heads and high discharges existing at this site. Economic analysis performed by NPD indicated that a single tubular turbine-generating unit would develop this site's potential.

The turbine would be rated to produce 10,150 HP at a net head of 33.0 feet. This corresponds to a generator output of 7.2 MW assuming a generator efficiency of 95%. The estimated runner diameter and speed of the turbine is 142 inches and 133.33 RPM, respectively. The actual speed, however, will be left to the discretion of the turbine-generator manufacturer. It is assumed the turbine will be connected to the generator through a speed increaser. The centerline elevation of the turbine is 682.00 fmsl. This elevation is based upon the estimated required submergence of the turbine for cavitation protection. Estimated turbine performance and overall operating net head and flow ranges are shown on Figure 4.1. These curves have been developed from existing manufacturers data and indicate the approximate performance of the turbine selected for evaluation of this site. When further studies are made, all appropriate configurations and turbine types will be considered.

4.04 Bulb Generator. The generator portion of the tube turbine generator will be of the horizontal shaft, synchronous type, with a speed increaser between the shaft and the turbine. It will be rated at 7.2 MW (8.0 MVA at 0.9 P.F.), 3-phase, 60 Hz, 13.8 kV, 900 RPM, with Class B

insulation, 75°C temperature rise. A drip-proof housing will be provided with connections for out-going ducts. The exact mechanical arrangement will be determined by the turbine/generator supplier. The generator will be furnished with manufacturer's standard type exciter. This could be a "High Initial Response" bus-fed static excitation system or a direct connected brushless exciter.

4.05 Governor. The governor will be of the oil pressure, pilot operated, distributing valve, cabinet actuator type with speed and power responsive elements designed to regulate the speed and power by controlling the wicket gate and blade operation. Speed responsive elements will be controlled by a speed signal generator directly connected to the generator shaft. The governor will consist of a cabinet actuator equipped with the necessary indicating and control devices, and an oil pumping set consisting of a sump tank and two motor driven oil pumps, one or two pressure vessels as required, all necessary blade and gate servomotor piping and a speed signal generator. In addition, an automatic gate limit control system will be provided for positive limiting of the turbine gate opening and preventing the turbine from exceeding cavitation limits under varying head conditions.

4.06 Mechanical Equipment.

H.V.A.C. Powerhouse cooling will be accomplished using outside air. Heating will be by electrical equipment heat loss and electric resistance back-up heater. Equipment will include an air handler, electric heater, louvers, ductwork and controls.

Cranes. A 85 ton gantry crane will be provided for the installation and servicing of the generator and turbine at elevation 667. The gantry crane will also have a 20-ton auxiliary hoist for handling the draft tube emergency flosure and intake stoplogs.

A barge mounted crane will be used to unload the heavy equipment from the barge to the tailrace deck at El. 709.6. A barge mounted or mobile crane will be used to install and remove the intake gate, bulkheads and trashracks. A mobile crane or barge mounted crane could also be used to handle trash.

Piping. Raw water for unit cooling and turbine glands will be taken from the penstock by gravity flow and strained. A small pump and filter will be required for gland water. One Governor air and two service air compressors will be provided. Unwatering and drainage will be handled by a dual pumping system and a common sump. Portable oil handling equipment and a pump for fire protection and deckwash will be provided. CO_2 cylinders with automatic and manual releases will be provided for the generator fire protection. Potable water will be supplied by an existing potable water line. The waste from the toilet will be pumped to the existing sanitary system.

4.07 Generator Voltage System. The connection between the generator and breaker will be with non-segregated phase bus. The generator and station service breakers will be metal clad drawout type rated 500 MVA (nominal), 13.8 kV 1200 amps continuous. The breakers will be combined in a common switchgear lineup along with generator surge protection and

instrument transformers.

4.08 Station Service. The station service power will be obtained via a tap between the generator breaker and the outgoing bus. The station service transformer will be adjacent to the generator switchgear lineup. Station service power distribution will be at 480 volts 3-phase and 120/240 volts single phase.

4.09 Connection to Load. 3-phase non-segregated phase bus will tie the plant to the existing 13.8 kV system in the Ford hydro plant. The bus will be connected to the powerhouses through a disconnect switch in the Ford hydro plant.

4.10 Control Equipment. A complete complement of generator and transformer protective relays, metering, synchronizing equipment and start-up and shut-down equipment will be located in a control switchboard near the unit. The control and protective scheme will be designed for attended manual start-up and loading, and will shut down automatically on a trouble condition. A single annunciation point will be wired to the lock control room to notify the operator of a trouble condition.

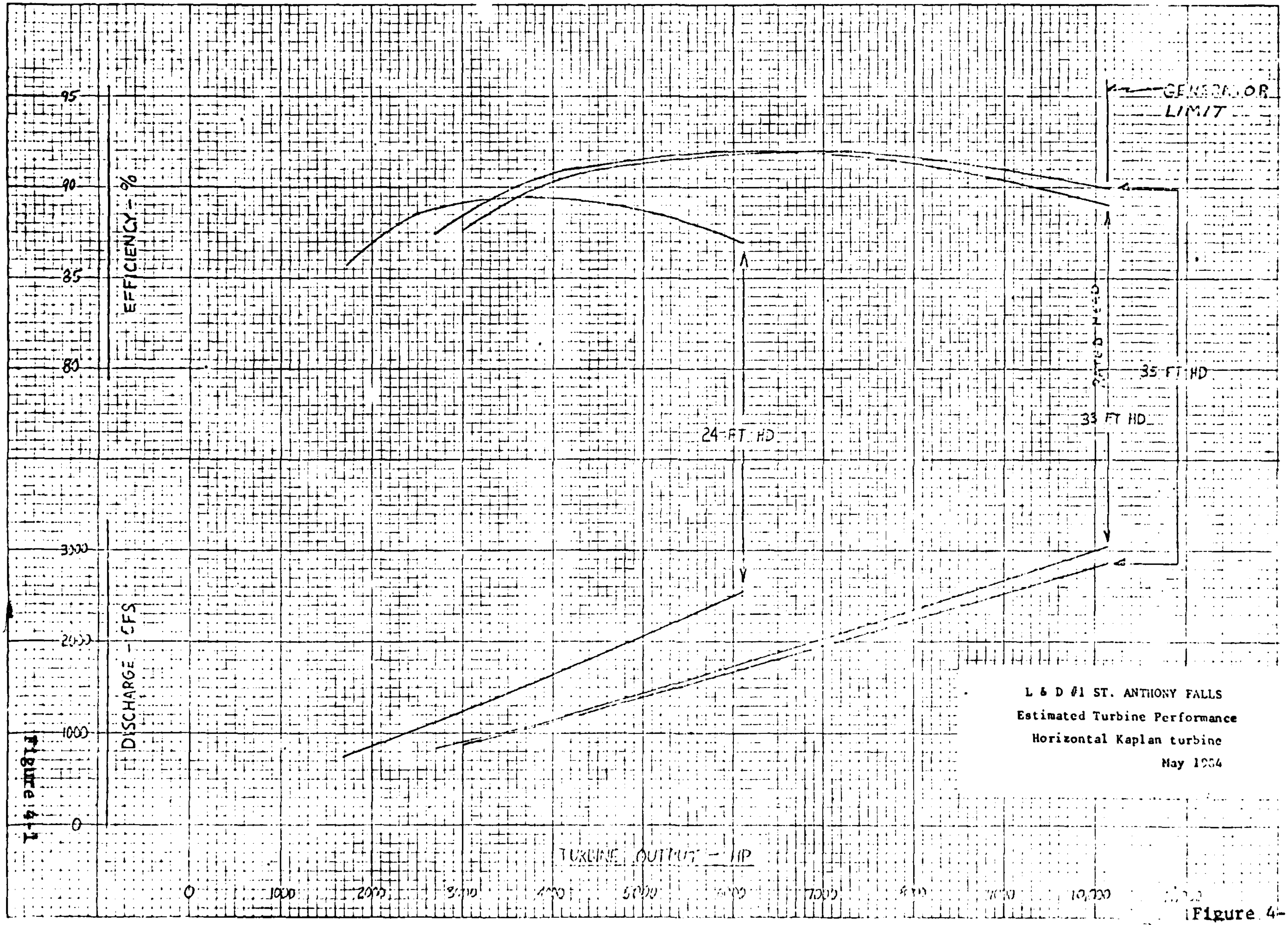
GENERATOR LIMIT
95
90
85
80
EFFICIENCY - %
3000
2000
1000
0
DISCHARGE - CFS
24 FT HD
33 FT HD
35 FT HD
TURBINE OUTPUT - HP
0
1000
2000
7000
10,000
L & D #1 ST. ANTHONY FALLS
Estimated Turbine Performance
Horizontal Kaplan turbine
May 1984

Figure 4-1

SECTION 5 - PROJECT COST AND SCHEDULE

5.01 Project Cost. An itemized [illegible]st estimate for the sele[illegible] .2 M[illegible] plant, Site D, is shown below in Table 5-1. For comparison costs for Sites A, B and C are shown in Table 6-5. Unit costs for labor and materials were based on Oct 83 price levels. The excavation feature includes Diversion and Care of Water, both of which were computed by St. Paul District.

All cost features include materials and labor required to provide a complete job. The Total Project Cost is 8,11[illegible],[illegible]00.00 and does not include any contingencies. Contingencies will be assessed at 15 percent for Turbine, Generator and Accessory Electrical Equipment; all other features were assessed at 20 percent, as shown on Table 6-2.

5.02 Design and Construction Schedule. The project design and construction schedule shown in Figure 5-1 is separated into two parts, the Powerhouse Design and Construction contract and the Turbine and Generator Design and Construction contract. The Powerhouse Design and Construction contract has a duration of 49 months. It is restricted by the turbine supply contract in 3 places. First, the construction contract is advertised after the turbine-generator contract is awarded. Secondly, the first stage concrete must be completed in order to set the embedded turbine parts. And finally, the second stage concrete must be completed in order to install the non-embedded turbine and generator parts. The total construction time, excluding design and review, is 28 months.

The Turbine and Generator Design and Construction contract has a duration of 47 months. The time required to supply embedded parts after awarding the turbine supply contract is 22 months. To supply the embedded parts after award of contract requires 22 months and the delivery of the non-embedded parts takes an additional 6 months. An additional 7 months is required to complete the powerhouse and test the turbine and generator before placing the unit on line. The total time of construction was measured from the award of the Turbine & Generator Supply Contract to the power-on-line. This was 35 months.

TABLE 5-1 COST ESTIMATE FOR 7.2 MW PLANT, ALTERNATIVE D.

PROJECT: LOCK AND DAM #1
PLANT CAPACITY: 7.2 MW
UNIT SIZE: 1-3600 mm Tube

DATE: MAY 1984
PRICE LEVEL DATE: OCT 82
LOCATION: St. Paul
RIVER: Mississippi River

FEATURE	COST
1. POWERHOUSE	
1.1 Excavation 1/	
a. Powerhouse Placement	150,000
b. Downstream Channel	50,000
c. Cofferdams	400,000
d. Dewatering	600,000
1.2 Reinforced Concrete	1,500,000
1.3 Misc. Building Items	100,000
1.4 Bulkhead, Guides & Struct Steel	250,000
1.5 Architectural	50,000
1.6 Access Bridge	200,000
2. TURBINE AND GENERATOR	
2.1 Turbine & Generator	3,000,000
2.2 Excitation Equipment	------- 2/
2.3 Governor	------- 2/
2.4 Cooling System	20,000
3. ACCESSORY ELECTRICAL EQUIP.	
3.1 Switchgear, Breakers & Busses 3/	70,000
3.2 Station Service Unit	65,000
3.3 Control System	154,000
3.4 Misc. Electrical Systems	75,000
4. AUXILIARY SYSTEMS & EQUIP.	
4.1 Heating and Ventilating	8,000
4.2 Station, Brake & Governor Air	30,000
4.3 Unwatering & Drainage Systems	40,000
4.4 Intake Gate Hoist	100,000
4.5 Misc. Mechanical Systems	40,000
4.6 Gantry Crane, Tailrace	500,000
5. SWITCHYARD	
5.1 Power Transformer	
5.2 Disconnects & Elec. Equip.	10,000
6. SITE PREPARATION & SPECIAL ITEMS	
6.1 Mobilization & Preparation	700,000
TOTAL	8,112,000

1/ By St. Paul District
2/ Included in 2.1 Turbines & Generators
3/ A portion of the switchgear is included in Feature 2.1 Turbines & Generator

LOCK & DAM #1 PROJECT

MISSISSIPPI RIVER, ST. PAUL, MINNESOTA

ALTERNATIVE D

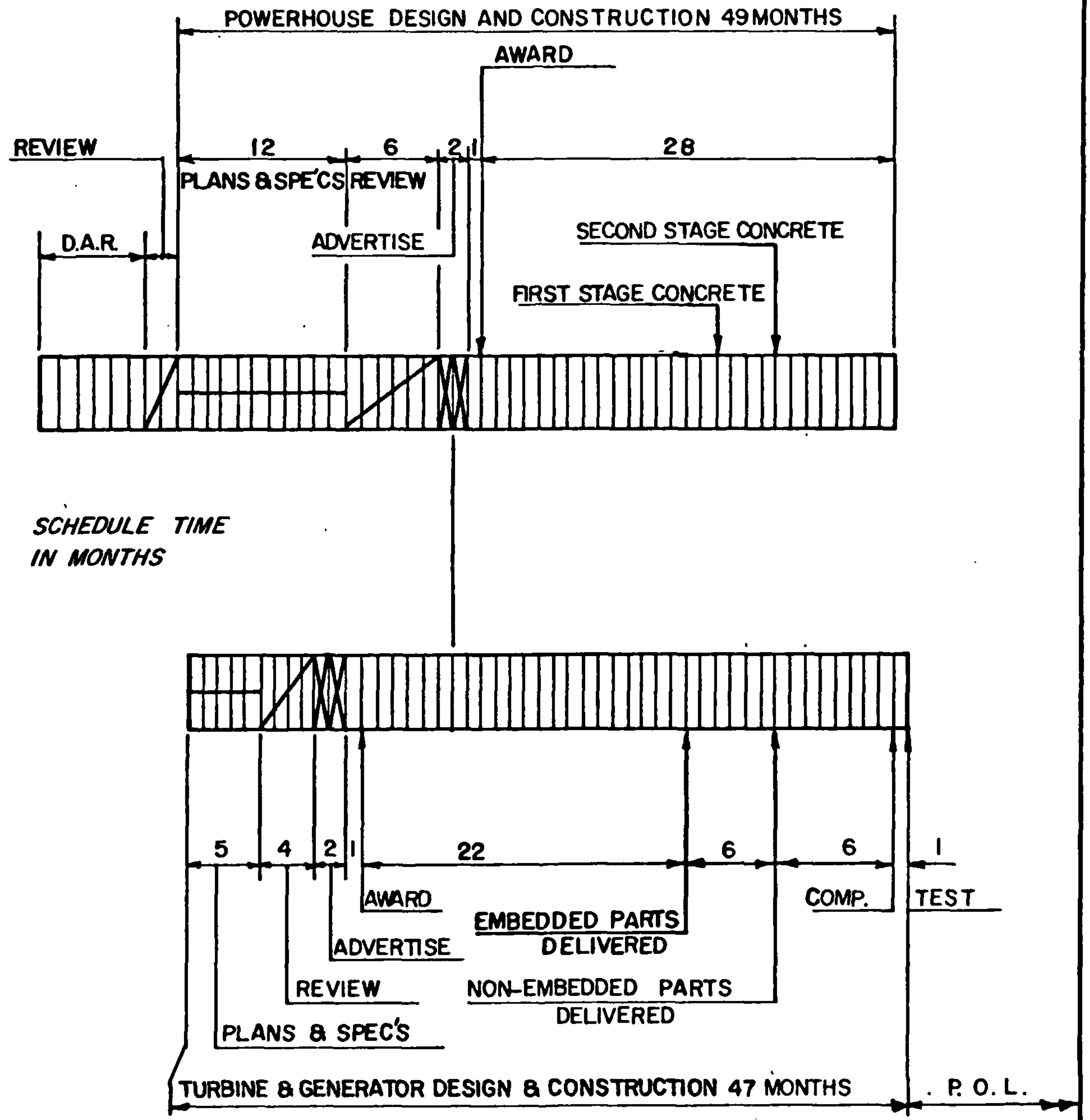

FIGURE 5-1 DESIGN AND CONSTRUCTION SCHEDULE

SECTION 6 - ECONOMICS

6.01 General. The purpose of this section is to estimate the economic value of the proposed power installation; the optimum size of the power plant will also be determined. Annual project costs for a range of plant sizes will be computed. The corresponding benefits based on power values provided by the Federal Energy Regulatory Commission (FERC) will also be determined. The power values are based on alternative development of a coal-fired thermal plant. A net-benefit analysis will then be made by comparing the annual cost to the annual benefits.

6.02 Cost Estimates. All cost levels in this report are based on October 1983 levels. Cost estimates were prepared for different sizes of generating plants that can utilize the available flows. For scoping it was found that construction costs varied nearly linearly with installed capacity. After the optimum plant size had been determined, a final, more refined cost estimate was developed for each site (also see Section 6.07 Scoping).

Initially, cost estimates were prepared for the four alternative powerhouse locations described in Section 4.02. Preliminary cost estimates were used in the scoping phases. Then when the selected plant was chosen, more detailed cost estimates were developed.

For the powerplant, engineering and design (E&D) cost of 6 percent and supervision and administration (S&A) costs of 6 percent were included. Because a large portion of the costs of the powerplant represents electrical and mechanical equipment purchased under supply contracts, E&D

and S&A costs represent a smaller portion of total project costs than for many other similar types of construction projects. To obtain the total investment cost, interest during construction was added based on a construction period of 35 months (see Section 5.02). Interest during construction (IDC) costs were compounded based on the estimated midpoints of yearly construction expenditures using a "rounded-off" 36 month period. Based on experiences with similar projects in North Pacific Division, the estimated yearly costs expressed as a percentage of the total cost for each site were as follows:

TABLE 6-1

TOTAL PROJECT EXPENDITURE PERCENTAGES

	Year 1	Year 2	Year 3
Powerplant Equipment 1/	60%	30%	10%
Items Exclusive of Powerplant Equip. 2/	10%	70%	20%

1/ Items 2 and 3, Section 5.01
2/ Item 1, 4, 5 and 6, Section 5.01

6.03 Cost Adjustment for Inflation During Construction. Construction cost estimates for feasibility level reports are based largely on bids made by contractors on similar projects. Since contractors must cover all costs over the entire construction period, their bid estimates include an allowance for increases in the price of labor and material (inflation) over the entire construction period. Water Resources Council (WRC) NED benefits manual,[1/] states that a project's NED benefit and cost must be computed at a common point in time. The NED benefits for this report are based on October 1983 price levels; therefore, an adjustment was made to the project cost estimate to arrive at NED costs for the same price level. Procedures for making allowance in the cost estimate for inflation is specified in Engineering Manual 1110-2-1301, dated 15 April 1982. Based on the experience of North Pacific Division, a 6.1 percent total inflation rate adjustment was made to the project cost estimate. This inflation rate was computed from several completed powerhouse using an average length of construction of 24 months.

The process for making the appropriate inflation costs adjustment involves the following steps:

a. From the total project cost, deduct the cost of the turbines and generators and their contingency allowances. Cost estimates for supply contract items (i.e. turbines and generators) are point estimates with

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1/ Water Resources Council, Procedures for Evaluation of National Economic Development (NED) Benefits and Costs in Water Resources Planning (Level C), December 14, 1979, Section 713.23.

inflation during construction provided for by escalating the contract payment at the time of delivery or partial payment.

b. An inflation adjustment is computed on the basis of an inflation rate of 6.1% compounded annually over the construction period.

c. The inflation adjustment is then subtracted from the total project cost. To this subtotal, engineering, design, supervision and administration--and interest during construction are added to derive the total investment cost (NED).

TABLE 6-2

INVESTMENT COST ($1,000)

Selected Plant Size 7.2 MW
(Single Tubular Unit)

	Powerplant Equipment 8/	Items Exclusive of Powerplant Equipment	Total
Subtotal 1/	$3,384	$4,728	$8,112
Contingencies 2/	508	946	
Subtotal	3,892	5,674	
Inflation Adjustment 3/	0	- 512	
Subtotal	3,892	5,162	
EDS & A 4/	467	619	
Subtotal	4,359	5,781	
IDC 5/	744	673	
Real Estate Requirement 6/	0	50	
Total NED 7/ Invest. Cost	$5,103	$ 6,504	$11,607

1/ Basic construction costs from Section 5.01.

2/ For powerplant equipment, use 15%; for items exclusive, use 20%.

3/ Adjustment for inflation during construction, items exclusive of powerplant equipment only; see Section 6.03.

4/ Engineering, design, supervision, and administration, 12%.

5/ Interest during construction, compounded from estimated yearly expenditures.

6/ For land rental, dredge materials and easement for construction.

7/ National Economic Development (NED) investment cost for scoping and economic excludes inflation during construction costs.

8/ Cost items 2 and 3 only from Section 5.01.

6.04 Annual Costs. The period of analysis for the projects is 100 years. The annual interest and amortization rate is 8 1/8 percent. Operation, and maintenance, costs are based on curves and procedures published in the Corps of Engineers' 1979 Hydropower Cost Estimating Manual 1/, adjusted to October 1983 price levels. These O&M costs, in-turn were increased by a factor of 1.5 to be comparable with procedures described in EM 1110-2-1701, Draft Jan 84, Section 8-5c. Replacement costs were computed based on actual items of expenditure, present worthed to their estimated economic life (from ER 37-2-10, change 23, 21 Sept 73, Chp 8, Appendix I), then amortized to the project life. It is assumed that operation of the plant will be automatic with manual start-up; however, personnel associated with the other project functions (navigation) could be called in on emergency conditions.

Table 6-3 summarizes annual costs for the selected plant size. The costs for all plant sizes considered are also shown in Tables 6-5(a) and 6-5(b) along with the corresponding annual benefits.

1/ Corps of Engineers, Hydropower Cost Estimating Manual, May 1979 (Rev. July 1981), pp. 46-49 (prepared by North Pacific Division for the Institute for Water Resources).

TABLE 6-3

ANNUAL COST ($1,000)

Selected Plant Size 7.2 MW

NED Investment Cost	$11,607
Annual Cost	
Interest & Amortization 1/	943
Operation & Maintenance 2/	86
Replacement 3/	6
Total	$ 1,035

1/ 8-1/8 percent and 100 years (I & A factor = 0.081283)
2/ See Section 6.04
3/ See Section 6.04

6.05 Power Values. Power benefits are based on avoided costs--the costs that would be incurred if the hydro project were not constructed. Hydropower project benefits are represented by the cost of the most likely alternative project, which would usually be a thermal generation plant. Hydro generation can displace thermal generation in two ways: (1) by displacing an increment of a new generating plant, or (2) by displacing the operation expenses of some existing power plants (energy displacement).

Discussions with FERC Chicago office indicated that generation from Lock and Dam No. 1 would be similar to the proposed generation at the St. Anthony Falls project and would most likely displace an increment of new coal-fired generation. Thus, the total power benefit will include both capacity and energy components, based on alternative coal-fired generation.

In their 11 October 1983 letter (Appendix D), FERC supplied unadjusted capacity and energy values based on 8-1/8 and 14 percent discount rates and at October 1983 prive levels. These values are shown below:

UNADJUSTED POWER VALUES
(provided by FERC)

	8-1/8 %	14 % 1/
Capacity	$149.40/kw-yr	$259.20/kw-yr
Energy	18.9 mills/kwh-yr	18.9 mills/kwh-yr

1/ The effect of increased interest rates is described in Section 6.10.

An adjusted energy value was also developed by FERC using DOE fuel escalation projections and a 1990 power-on-line date. The capacity value was adjusted by NPD using mechanical and thermal availabilities of 0.985 and 0.760 supplied by FERC and an operating flexibility credit of 5-percent. The adjusted capacity value was developed from the following relationship.

Adj. Capacity Value = (CV x HMA/TMA) x (HF)

where,

CV = annual investment cost of the thermal alternative

HMA = mechanical availability - hydro project = .985

TMA = mechanical availability - thermal project = .76

F = *operating flexibility credit* = 0.05

Thus the adjusted power values are as follows:

ADJUSTED POWER VALUES
(provided by FERC)

	8-1/8 %	14 %
Capacity 1/	$203.31/kw-yr	$352.72/kw-yr
Energy 2/	30.9 mills/kwh-yr	30.7 mills/kwh-yr

1/ adjusted by NPD

2/ adjusted by FERC

6.06 Annual Benefits. Project annual benefits were computed for the series of plant sizes shown on Table 3-2. The annual benefit is, therefore, the sum of the capacity and energy benefits. The energy benefit is the product of the annual energy output and the adjusted energy value. Likewise the capacity benefit is the product of the dependable capacity and the adjusted capacity value.

Table 6-4 summarizes annual costs and benefits for plant sizes investigated for Site D. These costs and benefits are also shown graphically in Figure 6-1.

TABLE 6-4
ANNUAL COSTS AND BENEFITS
For Project Scoping -- Using Tubular Units
(October 1982 Price levels, $1,000)

Installed Capacity	3.9 MW	7.2 MW	8.5 MW	11.1 MW	12.3 MW	14.4 MW
Number of Units	1	1	2	2	3	3
<u>Generation</u>						
Dep. Capacity MW 1/	1.5	2.4	2.6	3.2	3.5	3.8
Annual Energy Mwh	13,110	21,450	23,430	29,250	31,620	34,890
Plant Factor 2/	38%	34%	~~23%~~ 31%	~~31%~~ 30%	29%	28%
<u>Costs</u>						
Annual Cost 3/	770	1,035	1,290	1,510	1,740	1,910
Production Cost 4/ (mills/kwh)	59	48	55	52	55	55
<u>Benefits</u>						
Annual Capacity 5/	305	488	529	651	712	773
Annual Energy 6/	405	663	724	904	977	1,078
Total Annual 7/	710	1,151	1,253	1,555	1,689	1,851
Net Benefits 8/	- 60	116	- 37	45	- 51	- 59
B/C Ratio 9/	0.92	1.11	0.97	1.03	0.97	0.97

1/ From Table 3-1
2/ (Annual Energy, MWh)/(Installed capacity, MW x 8760 hr)
3/ Annual Cost for selected plant from Table 6.3.
4/ (Annual Cost, $)/(Annual Energy, kwh x 1000 mills/$)
5/ (Dependable Capacity) x $203.31/kw-yr
6/ (Annual Energy) x $.0309/kwh
7/ (Annual Cap. Benefit) + (Annual Energy Benefit)
8/ (Annual Benefit) - (Annual Cost)
9/ (Annual Benefit)/(Annual Cost)

6.07 Scoping. The project was scoped using a net benefit analysis. Unit power values were used as described in the preceeding section. Table 6-4, lists the annual costs and the annual benefits for the range of plant sizes used in this analysis. Figure 6-1, shows graphically these costs and benefits, while figure 6-2 shows the net benefits. The optimum plant size was then selected based on the maximum net benefit shown on this curve.

Figure 6-1 shows costs and benefits for several different types of powerplants. The selected plant was based on using tube type units. As described in Section 4, the maximum physical size of the tube type units was limited to a diameter of about 3600 mm. The cost curve on Figure 6-1 for the tube type units is a serie of "steps". These steps are the points (7.2 MW and 11.0 MW) on the curve where the largest physical sizes per unit for each plant that can be feasibly developed. The vertical portion of the steps represents the added cost of an additional unit but no incremental gain in energy.

Also shown on Figure 6-1 are cost curve and benefit curve for a single bulb-unit powerplant. It can be seen that the range of sizes for a bulb-unit is much larger than for a tube-unit. In the initial scoping phase of this project, using October 1982 levels for power values, a larger sized bulb unit plant (16 MW) was optimum and was economically feasible. Since adoption of October 1983 level power values, the bulb unit plant became economically infeasible. However, to provide a measure of comparison the bulb units are represented as supplemental curves on Figure 6-1. The optimum plant size was 16 MW using the original single bulb unit concept. Subsequently, as more detailed costs became available, the two alternative

sites (A and D) near the spillway section of the project, a three-unit tubular plant configuration became more economical. These costs and benefits are included in Table 6-5(a) and (b) in Section 6.08.

As discussed in Section 3.02, it was assumed that operation of the new powerplant will be very closely coordinated with the operation of the older existing plant. This is especially important in the operational transition from moderately low flows, when only the old plant will operate, to medium and higher flows, when both new and old plants will be operating. For example, as the river flows increase from a low-flow state to a higher-flow state the new plant would begin to operate; to affect this the old plant would momentarily back down, thereby allowing enough flow to the new plant to permit it to operate at its minimum hydraulic discharge. Once the total river flows increased beyond these minimum transition flows, both old and new plants would then operate at their best efficiencies. This same situation would occur when the streamflows were in a regressive state. It is beyond the scope of this study, to fully evaluate this situation, but an operating agreement between all plant entities will be necessary to accommodate this operating transition. The agreement should be relatively easy to accomplish. For example, an equivalent amount of energy could be provided to the old plant to offset the loss of generation during these periods.

6.08 Comparison of Alternative Powerhouse Locations. Initially four alternative powerhouse locations were investigated. These powerhouse configurations are described in more detail in Section 4.02. Alternatives A and B would be located on the left side of the existing powerhouse, while alternative C and D would be located on the right side of the existing

powerhouse, slightly downstream from the existing spillway (also see Plates 1, 3 and 4). The same head and flow characteristics were used for all of the alternatives.

To provide an economic base of comparison, scoping costs were developed and a net benefit analysis was made. Tables 6-5(a) and 6-5(b) lists the economic summary for the alternative locations based on the 7.2 MW selected plant size and a 16.0 MW plant. The 16.0 MW plant was used because it was the optimum size for a bulb unit. However, three-unit tubular plants were used for Sites C and D to develop the 16-megawatt capacity because of limitations on the foundation excavation. It can be seen from the cost curve (Figure 6-1) that costs for the single bulb unit plant ~~is~~ are slightly higher than the 3-unit tubular plant.

TABLE 6-5(a)
ECONOMIC SUMMARY
ALTERNATE POWERHOUSE LOCATIONS
(x $1,000)

	Location A Left Abutment (Surface Powerhouse)		Location B Left Abutment (Underground Powerhouse)	
Physical Data				
Plant Size	16.0 MW	7.2 MW	16.0 MW	7.2 MW
No. Units	1	1	1	1
Type Units	Bulb	Tubular	Bulb	Tubular
Cost (x$1,000)				
Powerplant Equipment 2/	6,935	3,384	6,935	3,384
Items Exclusive 2/	8,862	4,993	9,951	6,340
Construction Cost	15,797	8,377	16,886	9,724
Contingencies 5/	2,812	1,507	3,030	1,776
Subtotal	18,609	9,884	19,916	11,500
Inflation Adjust. 6/	-1,676	- 626	-1,078	- 680
Subtotal	16,933	9,258	18,840	10,814
ED S, & A 7/	2,032	1,111	2,261	1,298
Subtotal	18,964	10,368	21,101	12,112
Loss of Existing Gen. 3/	1,526	1,526	0	0
Subtotal	20,491	11,895	21,101	12,112
IDC 8/	2,871	1,622	2,936	1,523
Investment Cost	23,632	13,517	24,037	13,635
Land Adjust.	50	50	50	50
Total Investment Cost	23,412	13,567	24,087	13,685
I&A 9/	1,903	1,103	1,958	1,112
O&M 10/	128	86	128	86
Replacement 11/	10	6	10	6
Total Annual Cost	2,041	1,195	2,096	1,204
Total Annual Benefit 12/	2,001	1,151	2,001	1,151
Net Benefit	- 44	- ~~25~~ -44	- 95	- 53
B/C Ratio	0.96	~~0.98~~ 0.96	0.95	0.96

Footnotes: See next page

TABLE 6-5(b)
ECONOMIC SUMMARY
ALTERNATE POWERHOUSE LOCATIONS
(x $1,000)

	Location C Right Side Powerhouse (Adjacent)		Location D Right Side Powerhouse (Offset)	
Physical Data				
Plant Size	16.0 MW	7.2 MW	16.0 MW	7.2 MW [1]
No. Units	3	1	3	1
Type Units	Tubular	Tubular	Tubular	Tubular
Cost				
Powerplant Equipment [2]	7,982	3,384	8,037	3,384
Items Exclusive [2]	8,048	5,080	8,475	4,728
Construction Cost	16,030	8,464	16,512	8,112 [4]
Contingencies [5]	2,807	1,524	2,901	1,454
Subtotal	18,836	9,988	19,413	9,566
Inflation Adjust. [6]	- 813	- 513	- 917	- 512
Subtotal	18,024	9,475	18,496	9,054
ED S, & A [7]	2,163	1,137	2,220	1,086
Subtotal	20,187	10,612	20,716	10,140
Loss of Existing Gen. [3]	1,546	1,546	0	0
Subtotal	21,773	12,158	20,716	10,140
IDC [8]	2,530	1,652	2,969	1,417
Investment Cost	24,263	13,810	23,684	11,557
Land Adjust.	50	50	50	50
Total Investment Cost	24,263	13,860	23,734	11,607
I&A [9]	1,976	1,127	1,929	943
O&M [10]	128	86	128	86
Replacement [11]	13	6	13	6
Total Annual Cost	2,117	~~1,219~~ 1,219	2,070	1,035
Total Annual Benefit [12]	1,950	~~1,158~~ 1,151	1,950	1,151
Net Benefit	-167	-~~61~~ -68	-120	116
B/C Ratio	0.92	~~0.95~~ 0.94	0.94	1.11

Footnotes: See next page

1/ Selected plant all cost data taken from Table 4-1.

2/ Alternative D from detailed cost Table 4-1, alternatives A B, and C proportioned from scoping costs.

3/ Alternative A and C cause partial shut-down of existing plant during construction. For loss of generation (disbenefits) see Appendix A.

4/ Total detailed construction cost of selected plant for alternative D (Table 4-1); for alternatives A, B and C scoping costs used.

5/ For alternative D, 15% of powerplant equipment items 2 and 3 (Table 4-1), 20% of items exclusived of powerplant equipment; for alternatives A, B and C contingencies proportioned accordingly.

6/ For alternative D from Table 6-1; for alternatives A, B and C proportioned.

7/ Engineering, design, supervision, and administration; use 12%.

8/ Interest during construction; for alternative D compound interest to midyear of construction (also see Section 6.02); alternatives A, B and C proportioned accordingly.

9/ Interest and amortization; 8-1/8 percent for 100 years.

10/ Operation and Maintenance, see Section 6.02.

11/ Replacement, see Section 6.02.

12/ See Section 6.06.

TABLE 6-6
ANNUAL BENEFIT COMPARISON
SUMMERTIME vs WINTERTIME PEAK, $1,000
(For selected 7.2 MW plant)

	July-August 1/ Critical Months ($1,000)	December-January Critical Months ($1,000)
Energy Benefit	663	663
Dependable Capacity	2.4 MW	0.71 MW
Capacity Benefit	488	144
Total Benefit	1,151	807
Net Benefit	116	-228

1/ All values from Table 6-4.

Table 6-6 shows that the dependable capacity based on the winter months would be less than half that of the summer months. Further, if the capacity benefit is combined with the energy benefit, the total benefit would be reduced nearly one-third. The net benefits would be substantially reduced such that the project would be economically in feasible. Again, this comparison is only a sensitivity test to provide additional information for the marketability analysis. The appropriate critical load months for determining dependable capacity are July and August.

From Table 6-5(a) and 6-5(b) it can be seen that the one-unit tubular plant at Site D is the best site base on economics. Site D is also economically feasible for a two-unit, 11 megawatt development; (see Figure 6-1) however, the net-benefit would be lower. Alternative locations A and C would cause loss of generation at the Ford plant during the construction phase. Alternative location B (underground) could create foundation problems; also the high cost of tunneling and evacuation make this location prohibitive. Alternate location D, by being offset 69 feet to the right of the Ford plant, would not cause any loss of generation during construction. When additional design data becomes available, a two-unit larger capacity plant could become more desirable -- or one of the other alternatives could be selected.

6.09 Comparison: Summertime vs. Winterime Dependable Capacity. As discussed earlier, project benefits were derived from the average annual energy and the dependable capacity of the plant.

The dependable capacity is based on the hydro project's performance in the months of peak power demand. While the region experience both summer and winter peaks, the summer peak is somewhat higher at the present time, and it is expected to become more predominent as the region's air conditioning demand grows. For these reasons, FERC recommended that dependable capacity be based on project output in the months of July and August. However, to compare the two seasons, a sensitivity analysis was made to determine the impact of basing dependable capacity on the project's performance during the winter peak demand months of December and January. Table 6-6 shows the project benefits for the selected plant sizes for each site.

6.10 Comparison: Interest Rates and Periods of Economic Analysis. The economic analysis used in this study was based on the Federal Interes Rate of 8 1/8 percent and a project life of 100 years. To evaluate the effect at higher interest rates and shorter economic life, analyses were made at 14-percent and at a 50-year project life. Project economic value were developed and are presented in Table 6-7 below. These values are intended for sensitivty and are supplemental to the general economic analysis of the project. The values are listed only for the 7.2 megawatt select plant D. Also only two interest rates and two periods of economic analysis are used; the effect at other interest rates or economic periods may be determined by interpolation.

TABLE 6-7
COMPARISON: INTEREST RATES AND PERIODS OF ECONOMIC ANALYSIS
(for 7.2 MW selected size, Site D)

Interest Rate	Annual 1/ Cost ($1000)	Annual 2/ Benefit ($1000)	Net Benefit ($1000)	B/C Ratio
100-Year Period of Analysis				
8 1/8%	$1,035	$1,151	116	1.11
14%	1,870	1,151	- 719	0.62
50-Year Period of Analysis				
8 1/8%	$1,054	$1,151	97	1.09
14%	1,872	1,151	- 721	0.61

1/ Costs for 8 1/8% and 100-year life from Table 6-3; other costs developed from using appropriate interest rates and periods off analysis.

2/ Benefits for 8 1/8% from Table 6-4; Benefits for 14% based on adjusted power values Section 6.05.

6.11 Marketability. Generation from the project would appear to be marketable. Because the project is relatively small, a thorough marketing analysis is not required. Discussions with Chicago office of the Federal Energy Regulatory Commission indicate that the generation can be readily absorbed into the area power load. The region's electric load is supplied through the Mid-America Power Pool (MAPP). Of the many utilities that supply MAPP, there are several relatively large cooperative utilities who are preference customers and indicate need for future generation in their systems.[1/] Preliminary discussions with DOE's office at Power Marketing and Coordination indicate that the generation can be marketed through DOE (see phone log dated 9 May 1983 in Appendix C). A formal marketability statement from DOE will be included in the feasibility report, confirming that the power from the recommended projects can be marketed and that costs

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1/ US Department of Energy, Power Marketing: Great Lakes Area (Draft), January 1981, Chapter, III.

can be repaid with interest in 50 years, as required by the 1944 Flood Control Act. Because the recommended project is smaller than 80 MW, the marketability statement will also serve to confirm the need for future generation. 2/

Figure 6-3, shows the annual distribution of energy at the project. The figures show that the spring and early summer months produce the major portion of energy; however the summer to early winter months do produce a substantial amount of energy. Only during the peak winter months (Dec, Jan, Feb) would the energy production be substantially reduced.

2/ Water Resources Counsel, Procedures for Evaluation of National Economic Development Benefits in Water Sources Planning (Level C), Section 713.601.

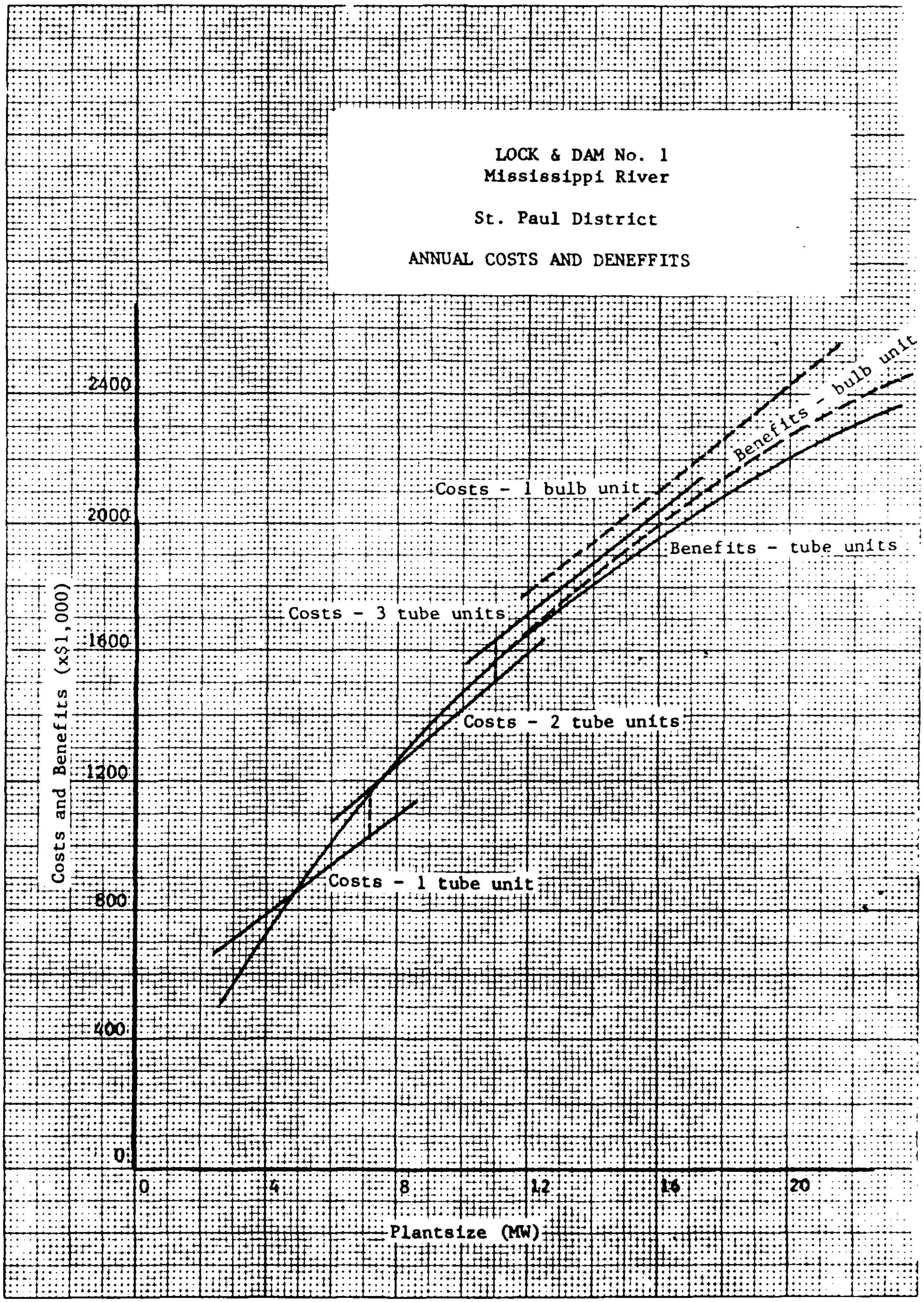
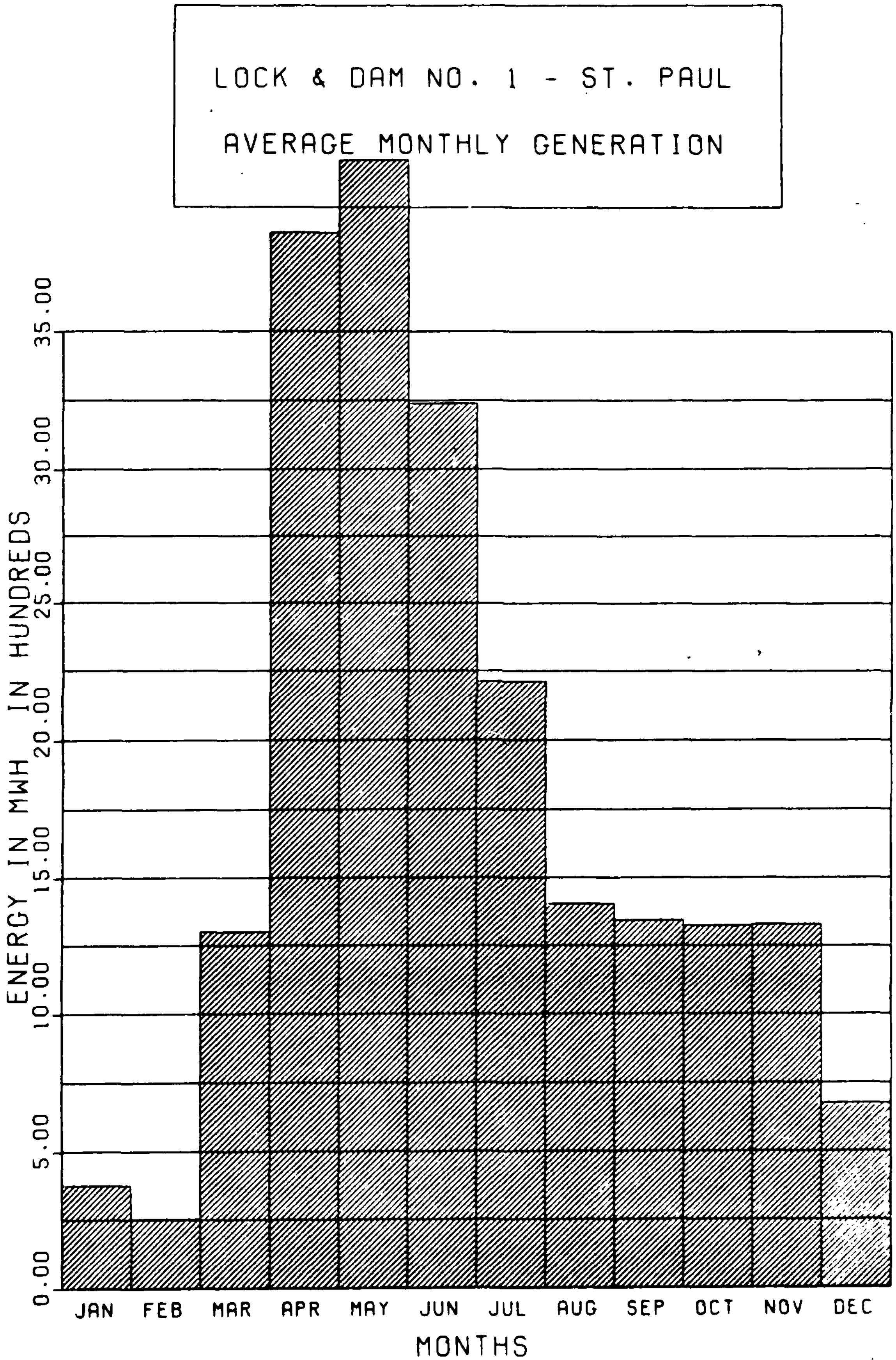

LOCK & DAM No. 1
Mississippi River
St. Paul District
ANNUAL COSTS AND DENEFFITS
Costs and Benefits (x$1,000)
Plantsize (MW)
Costs - 1 bulb unit
Benefits - bulb unit
Benefits - tube units
Costs - 3 tube units
Costs - 2 tube units
Costs - 1 tube unit
2400
2000
1600
1200
800
400
0
0
4
8
12
16
20

Figure 6-1



LOCK & DAM NO. 1 - ST. PAUL
AVERAGE MONTHLY GENERATION
ENERGY IN MWH IN HUNDREDS
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MONTHS

Figure 6-3

SECTION 7 - CONCLUSION

Additional power generation at Lock and Dam Number 1 on the Mississippi was analyzed using the existing project streamflows. The existing powerplant, built in 1924 by the Ford Motor Company has been in operation continually since. The plant has an installed capacity of 14.4 megawatts and operates at an annual plant factor about 75 percent. A basic assumption for the analysis in this report was that the new plant will not alter the existing plant's operation; therefore, the new plant will operate only during times when there is sufficient river flows for the existing plant to operate.

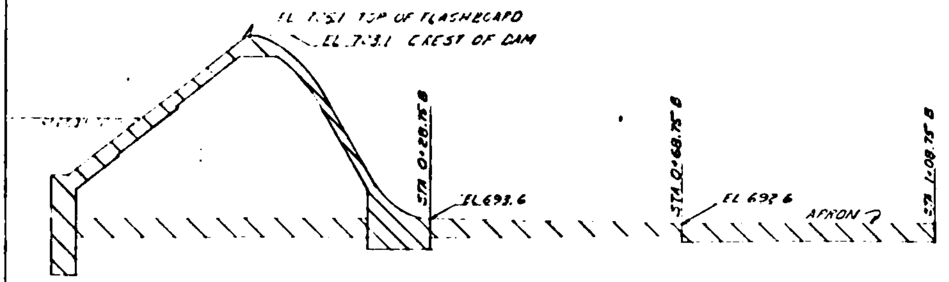
Four alternative powerhouse sites were investigated -- two on each side of the existing powerhouse. The selected plant is a single-unit tubular type located 69 feet to the right of the existing Ford plant. An access bridge is required to connect the new plant with the Ford plant. The selected plant size is 7.2 megawatts and the annual energy output is 21,450,000 kwh.

The total NED investment cost for the plant will be $11,607,000 while the annual cost will be $1,035,000. The project is economically feasible with a benefit-to-cost ratio of 1.11.

The generation will be marketable in the present power system. The power system is located in the Mid-American Power Pool (MAPP). Several large cooperatives utilities (preference customers) are members of MAPP.

While the project is relatively small, it can make a contribution to the regional power needs. As a measure of comparison the total project energy would produce the equivalent need for about 3,200 residential homes in the area. 1/

1/ Based on U.S. Department of Energy Publication Statistics of Privately Owned Electrical Utilities in the United States - 1980 annual residential usage of 6,800 kwh.



SECTION - EXISTING
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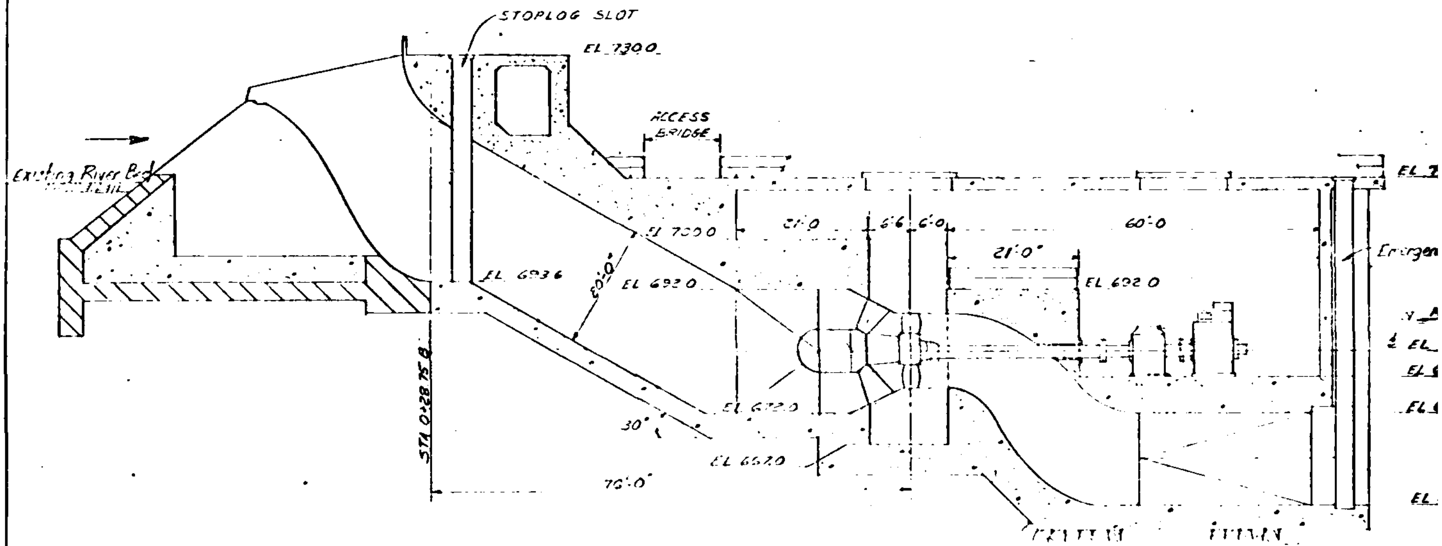
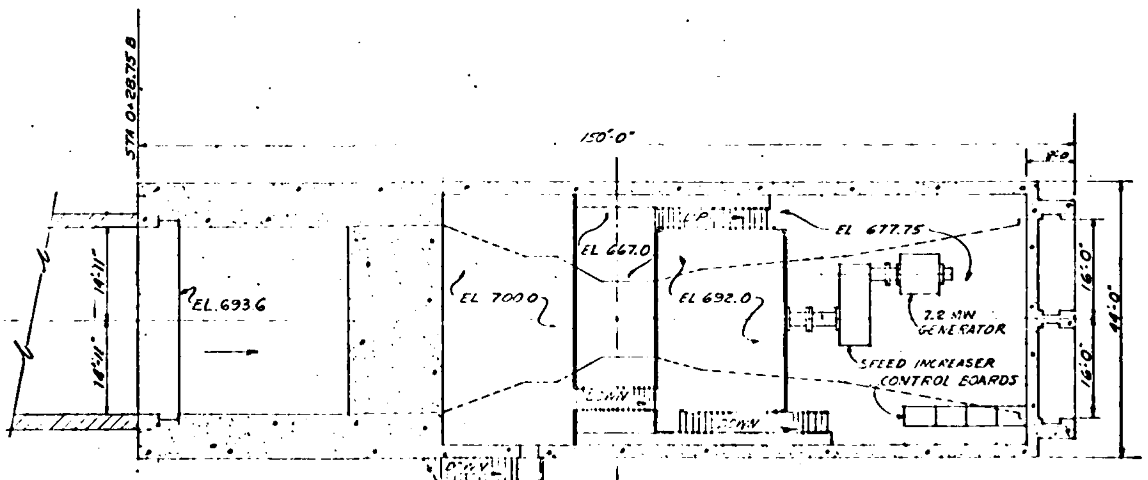
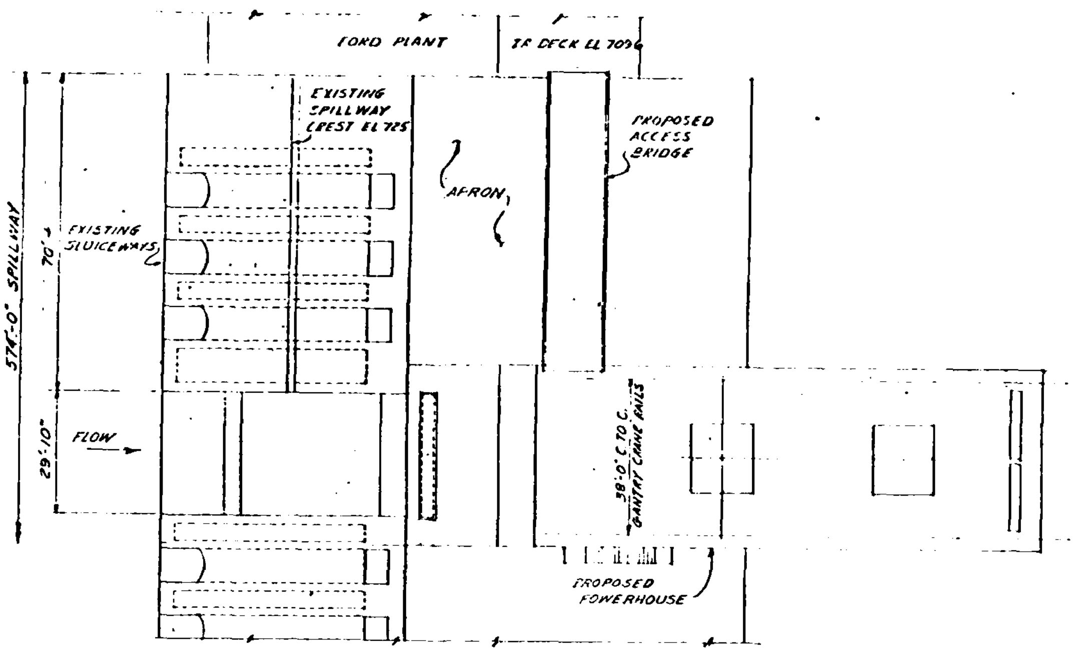


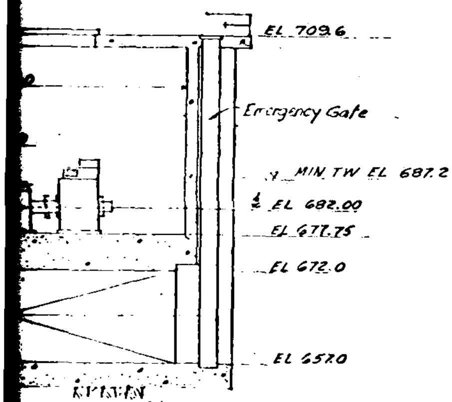
TRANSVERSE SECTION
3/32" = 1'-0

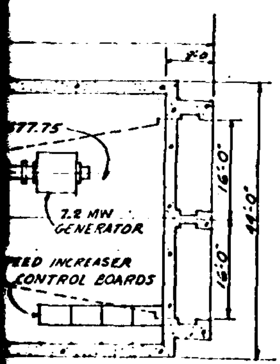


PLAN EL. 700.0
3/32" = 1'-0



SITE PLAN
NO SCALE





REVISION	DATE	DESCRIPTION	BY

U. S. ARMY ENGINEER DIVISION, N. P.
PORTLAND, OREGON

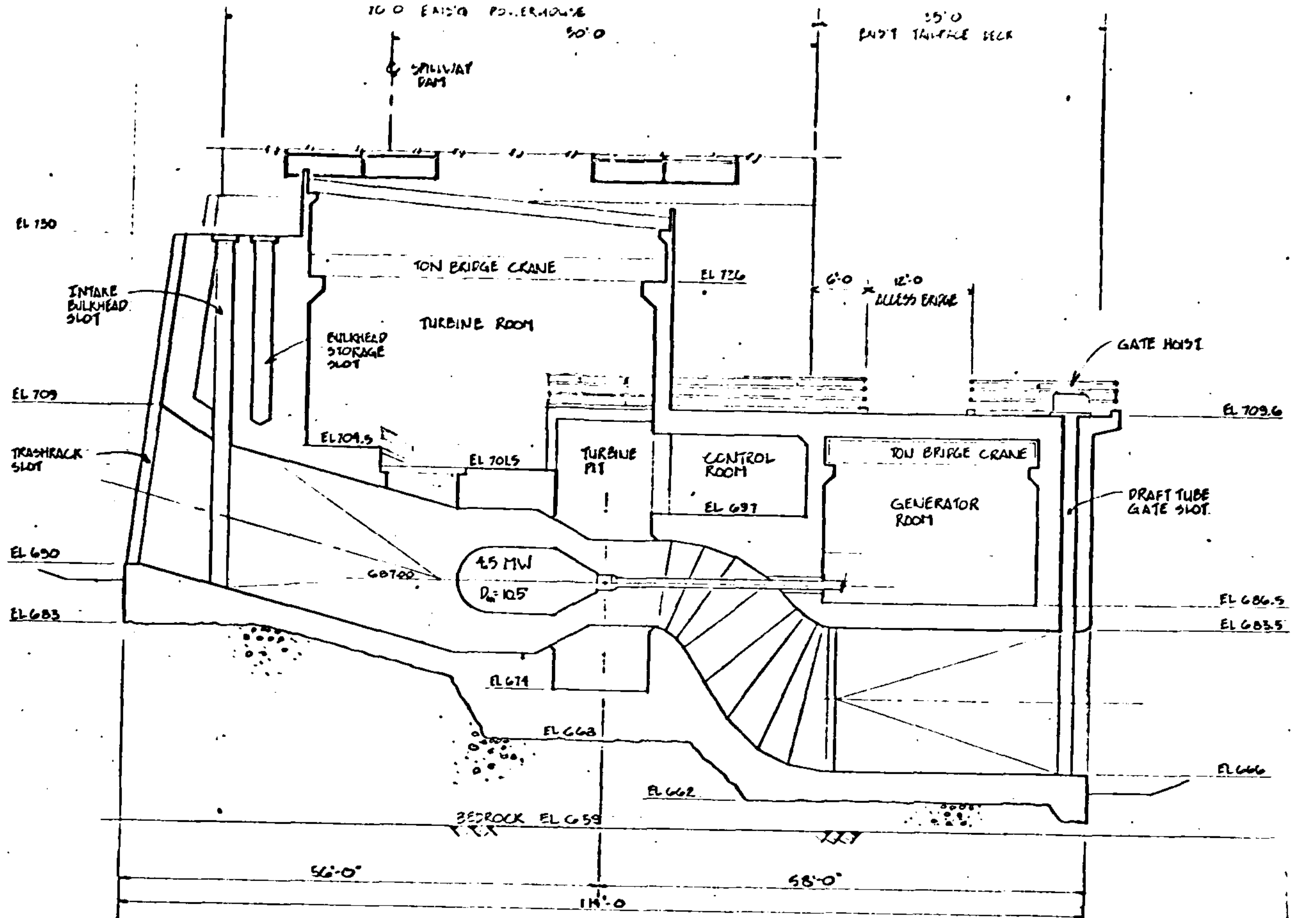
DESIGNED BY J.K.J.
DRAWN BY
CHECKED BY K.J.L.

LOCK & DAM #1 PROJECT
MISSISSIPPI RIVER MINNEAPOLIS, MINNESOTA
GENERAL
ALTERNATIVE D
1-TUBULAR UNIT
7.2 MW PLANT

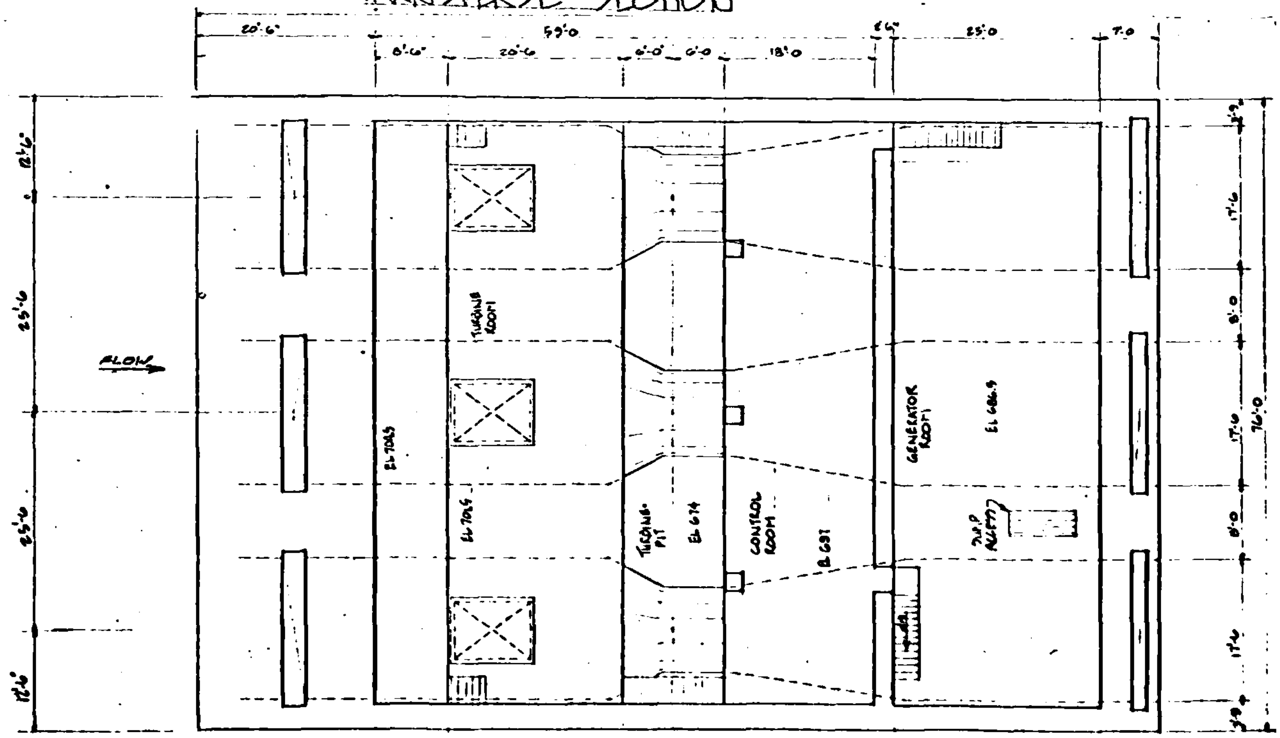
SCALE AS SHOWN

PLATE I

2



TRANSVERSE SECTION



PLAN

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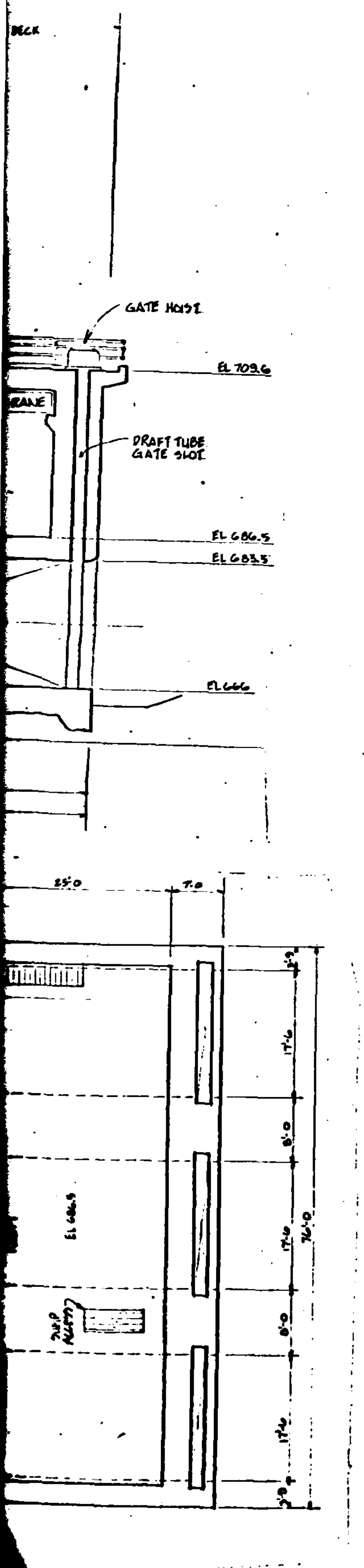
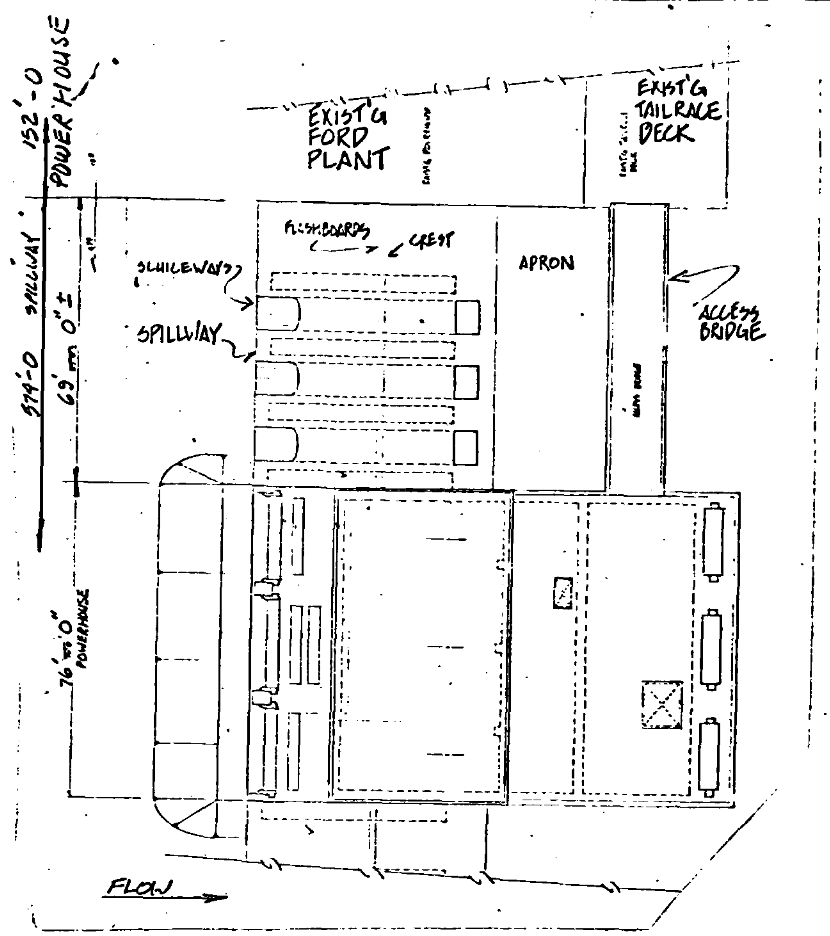




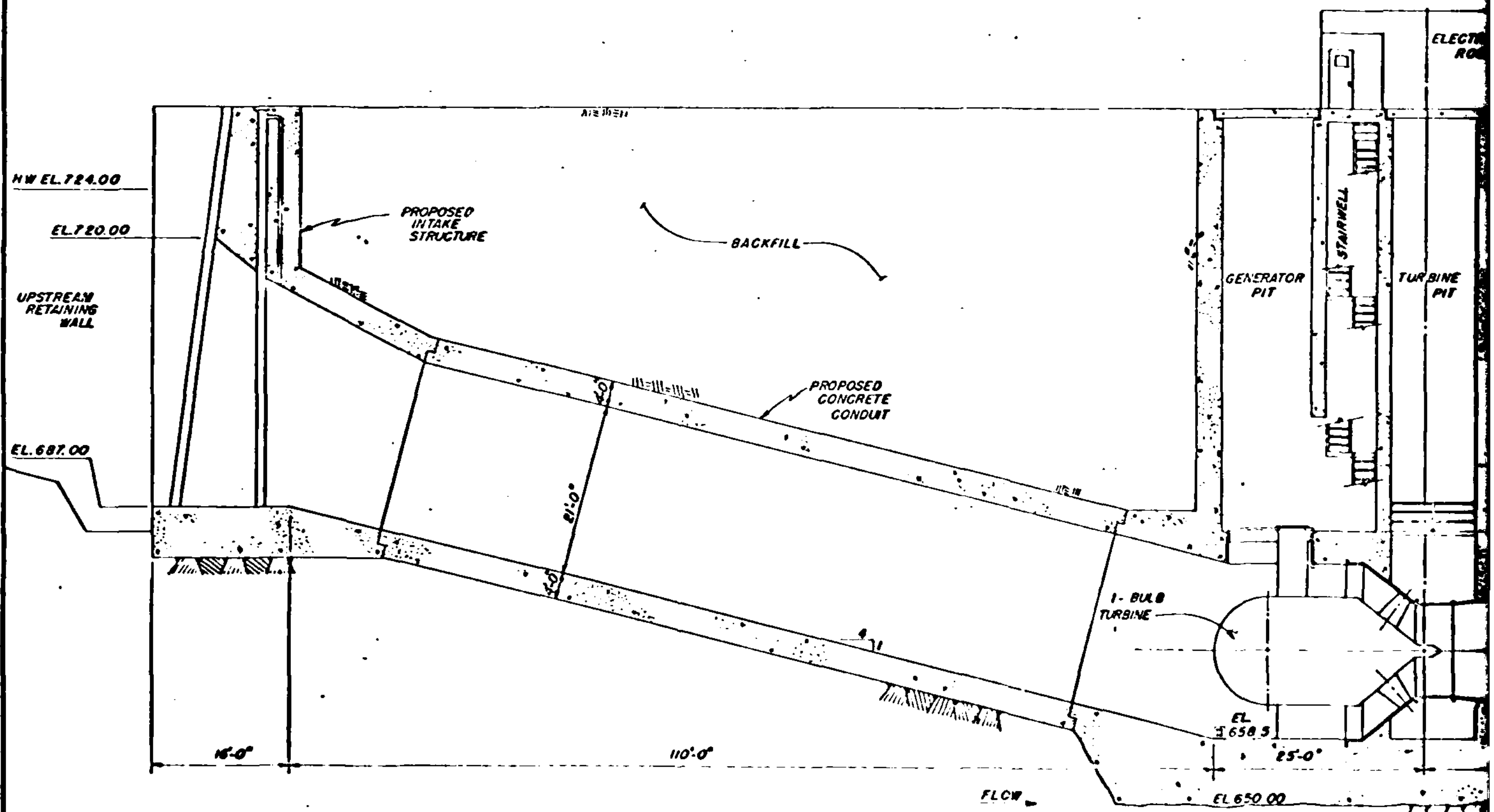
U. S. ARMY ENGINEER DIVISION, N. P.
PORTLAND, OREGON

LOCK & DAM #1 PROJECT
MISSISSIPPI RIVER MINNEAPOLIS, MINNESOTA
GENERAL
ALTERNATIVE D
3 TUBULAR UNITS
7.2 MW PLANT

DESIGNED BY JKJ
CHECKED BY KJL

SCALE AS SHOWN

PLATE 2



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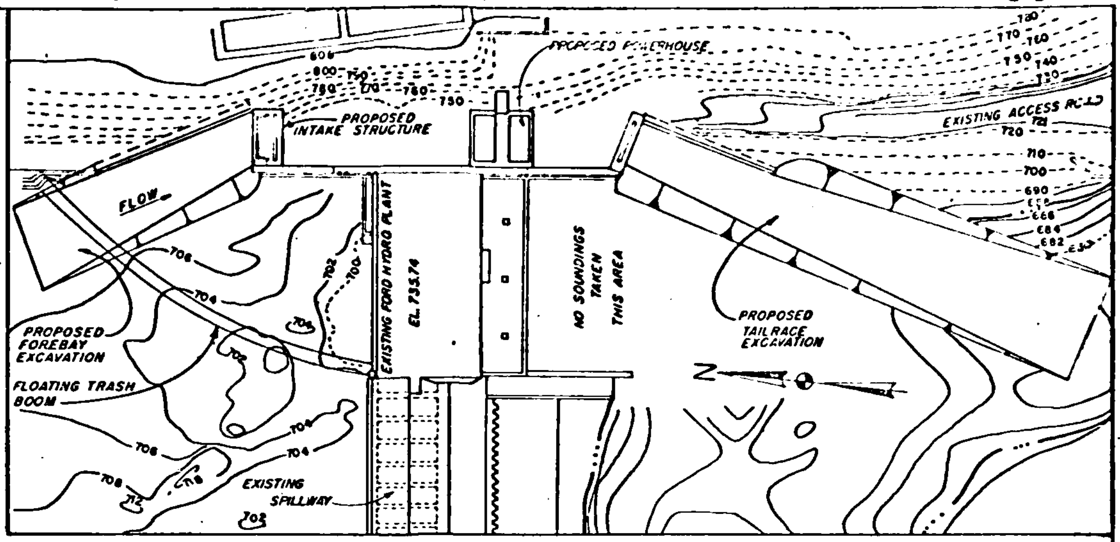
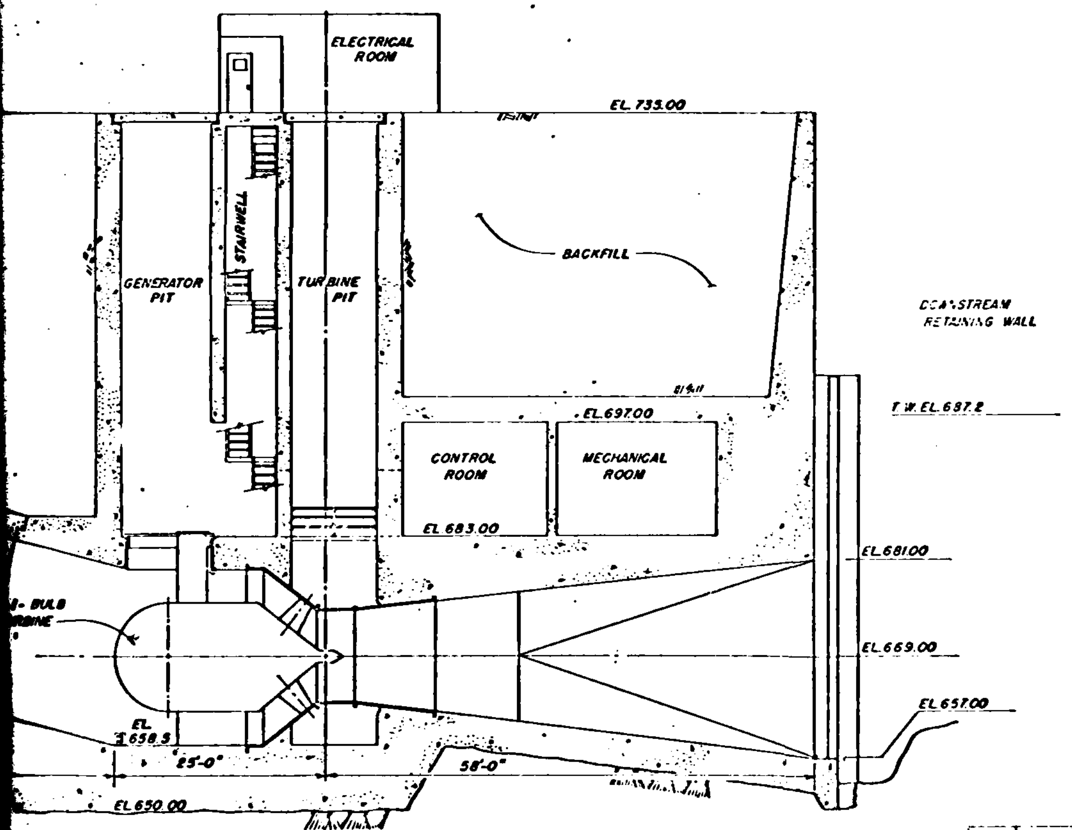


SITE PLAN

1" = 50'



TRANSVERSE SECTION

GRAPHIC SCALE

$\frac{1}{8}$" = 1'-0"

U.S. ARMY ENGINEER DIVISION, N.P.
PORTLAND, OREGON

LOCK & DAM #1 PROJECT
MISSISSIPPI RIVER ST. PAUL, MINNESOTA

GENERAL
ALTERNATIVE A
1-BULB UNIT
16.0 MW PLANT

SCALE AS SHOWN | SPEC. NO.

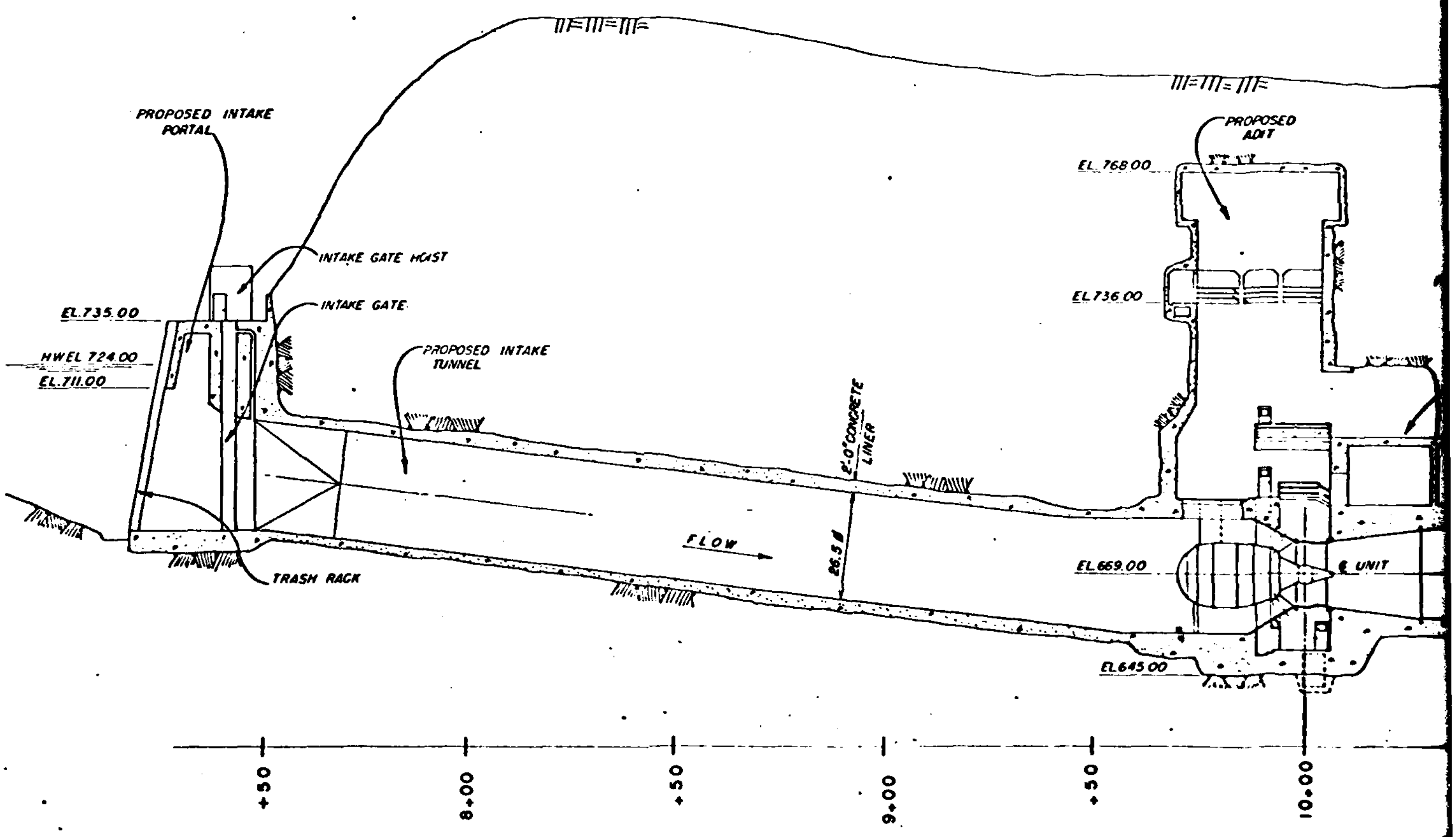
PLATE 3

2

D

C

B



TUNNEL CROSS SECTIO

SCALE: 1/16" = 1'-0"

A

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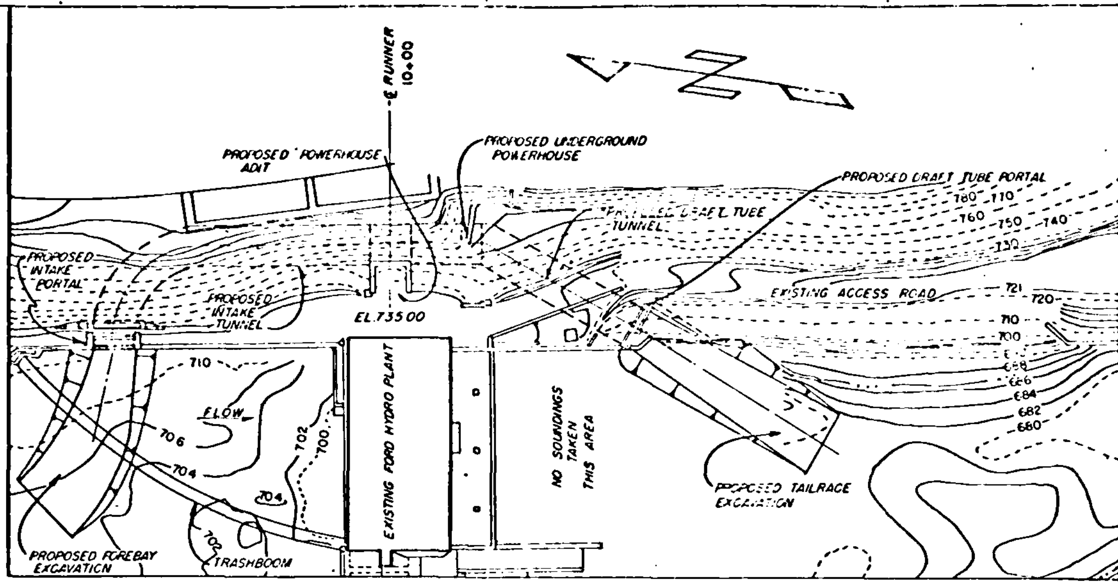
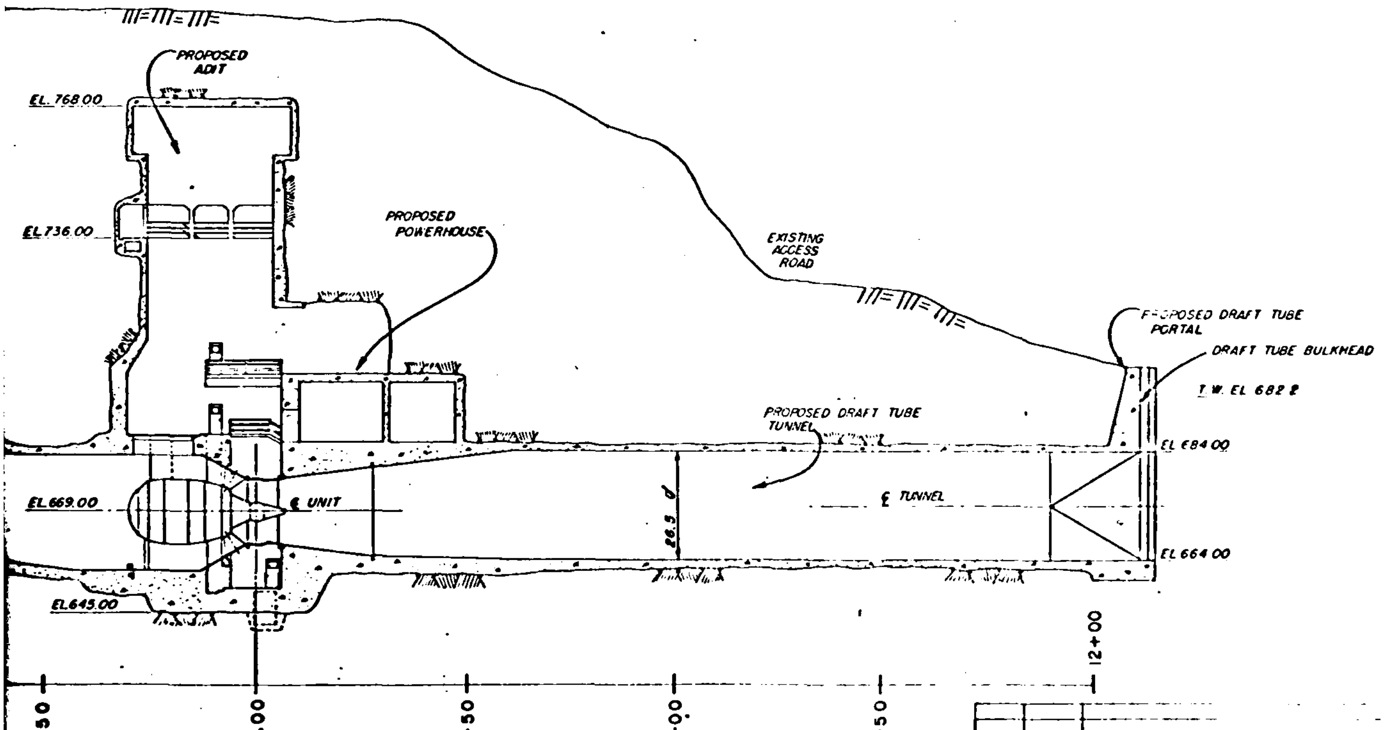


SITE PLAN

1" = 50'



TUNNEL CROSS SECTION

SCALE: 1/16" = 1'-0"

GRAPHIC SCALE

1/16" = 1'-0" 0 8' 16' 24' 32' 40'

U.S. ARMY ENGINEER DIVISION, N.P.
PORTLAND, OREGON

LOCK & DAM #1 PROJECT
MISSISSIPPI RIVER ST. PAUL, MINNESOTA

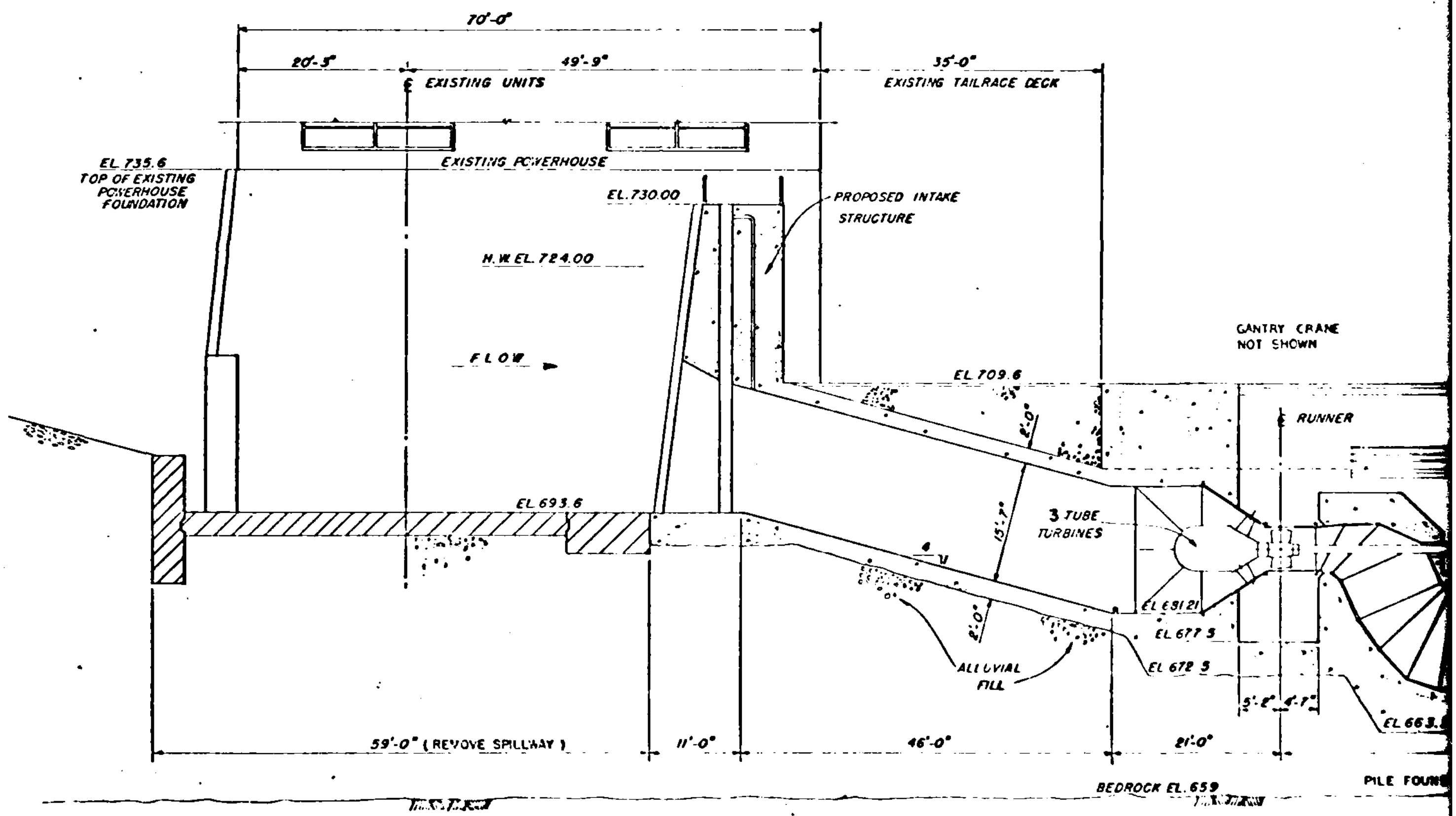
GENERAL
ALTERNATIVE B
1-BULB UNIT
16.0 MW PLANT

DESIGNED BY J.K.L.
DRAWN BY P.R.
CHECKED BY K.Z.L.

SCALE AS SHOWN

PLATE 4

2



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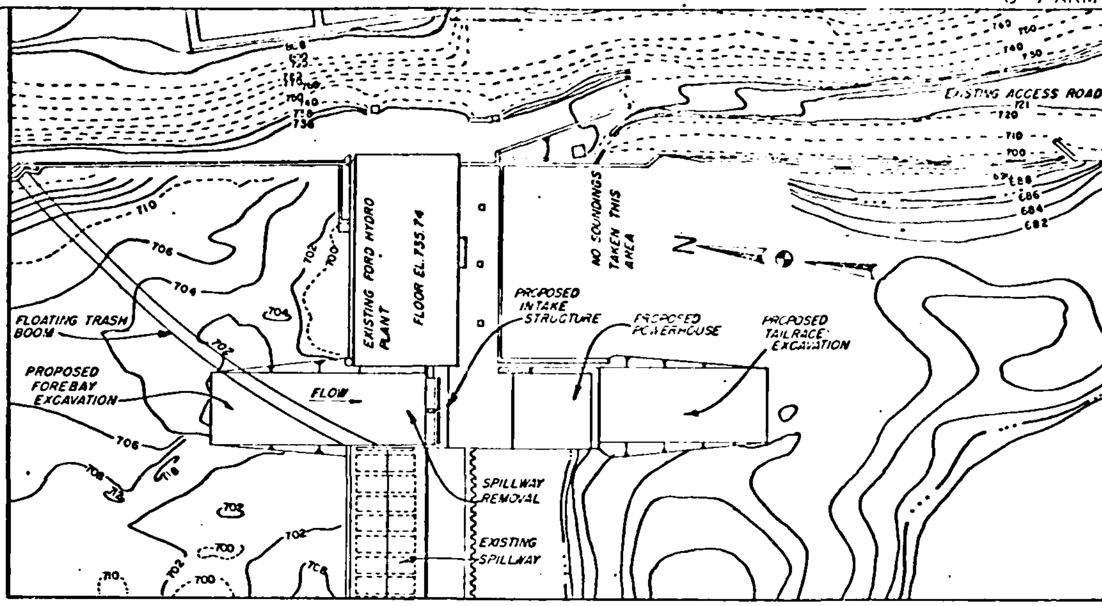
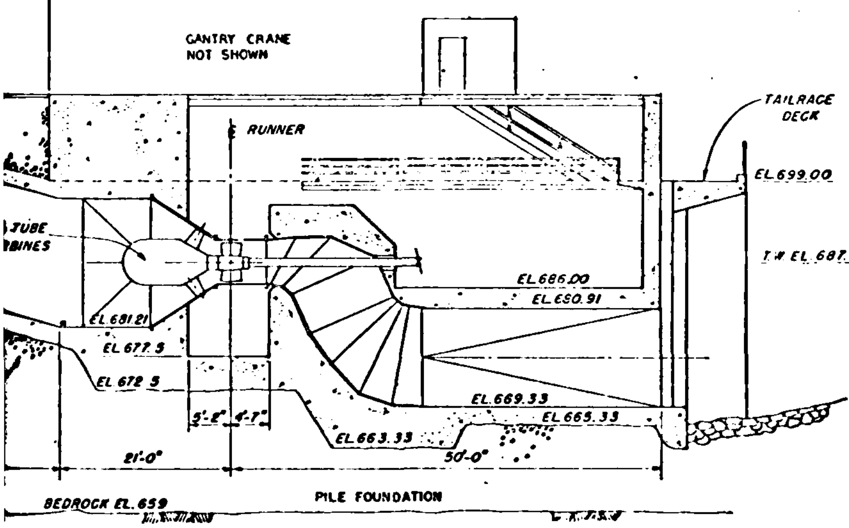


SITE PLAN

1" = 50'



CTION

GRAPHIC SCALE

U.S. ARMY ENGINEER DIVISION, N.P.
PORTLAND, OREGON

LOCK & DAM #1 PROJECT
MISSISSIPPI RIVER ST. PAUL, MINNESOTA

GENERAL
ALTERNATIVE C
3 TUBULAR UNITS
16.0 MW PLANT

SCALE: AS SHOWN SPEC. NO.

PLATE 5

2

APPENDIX A

Detailed Cost Estimates for Items Exclusive of Powerplant

APPENDIX B

Monthly Flow-Duration Curves

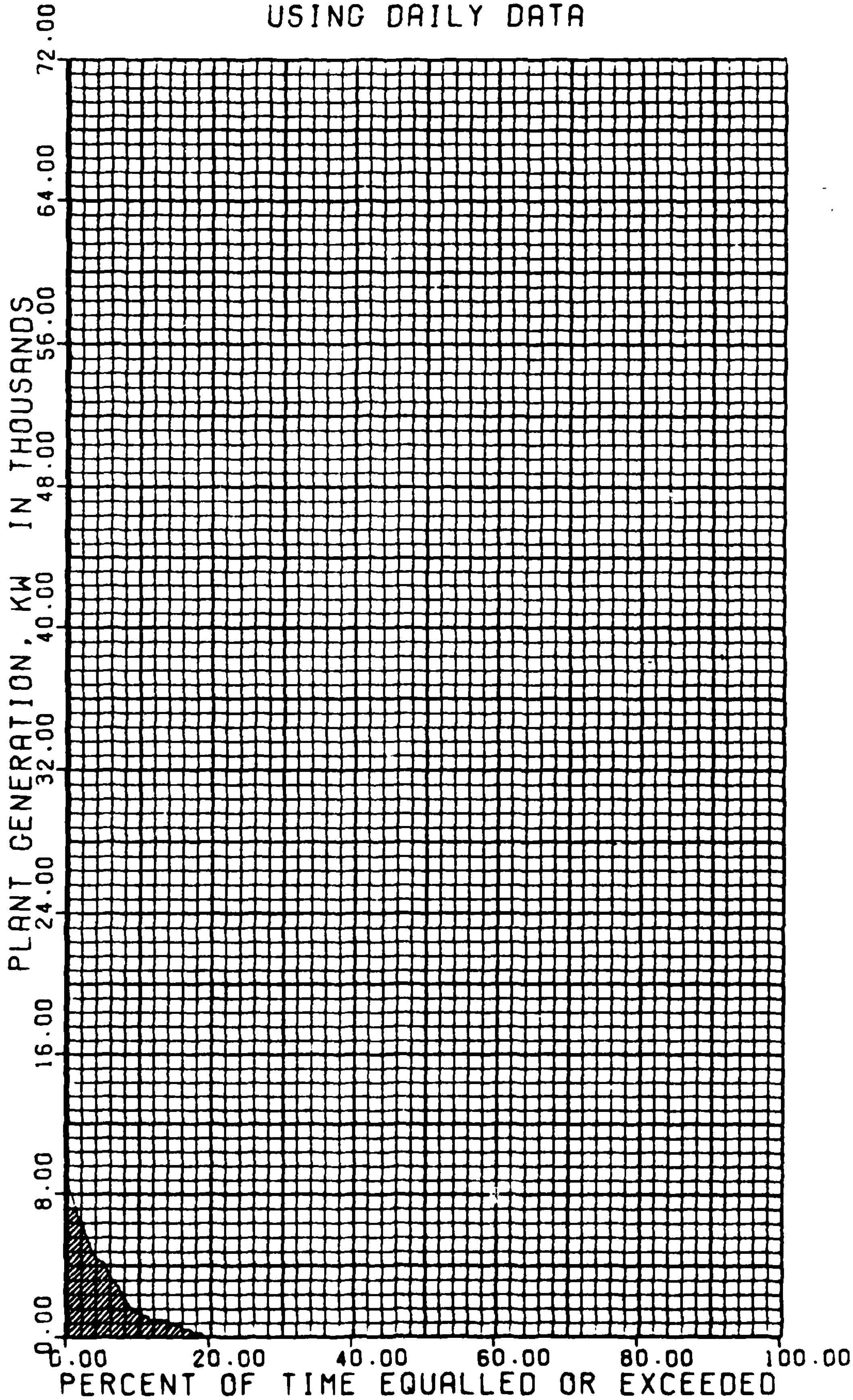
Monthly Flow-Duration Curves

(to be added later)

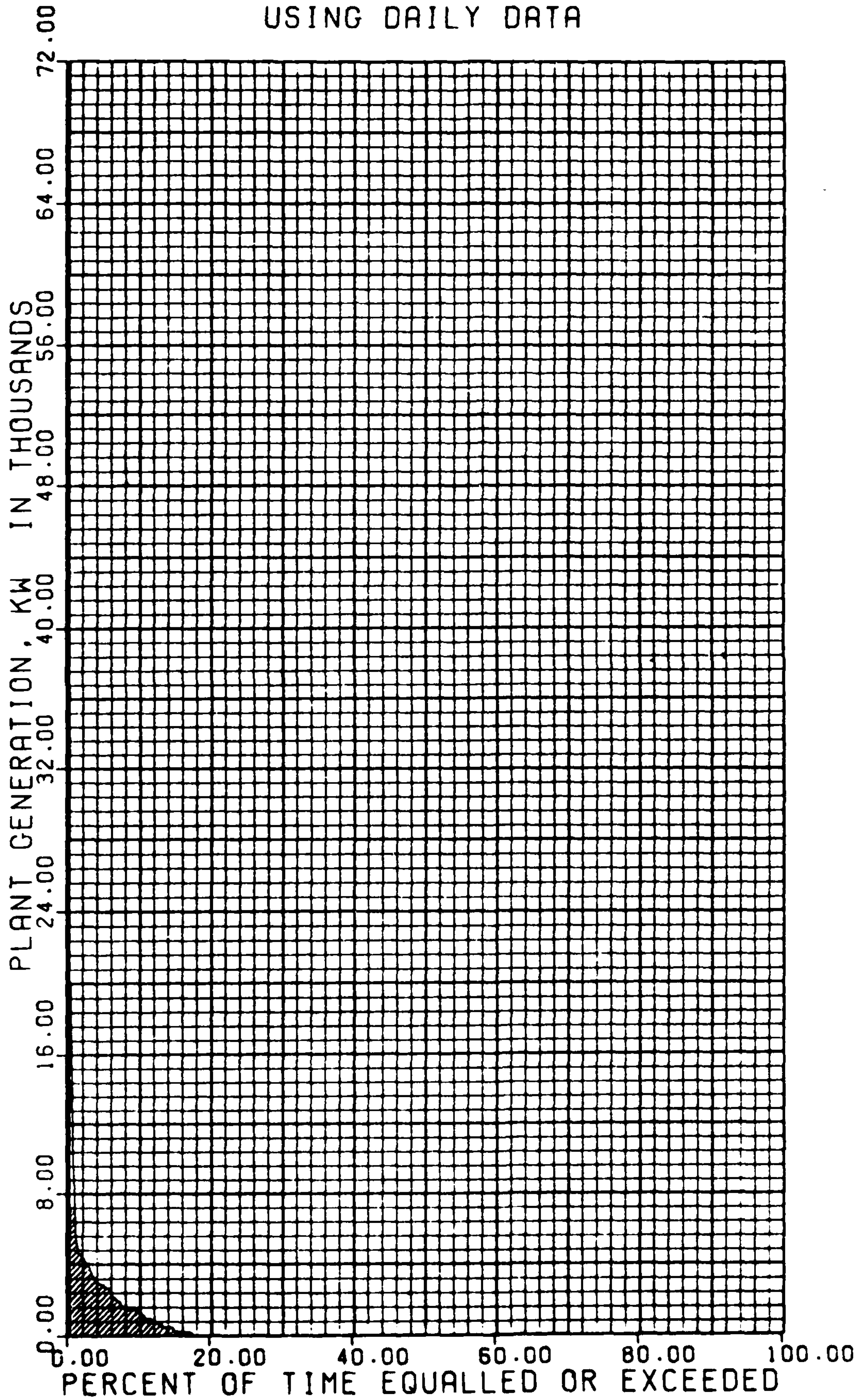
APPENDIX C

Monthly Power-Duration Curves

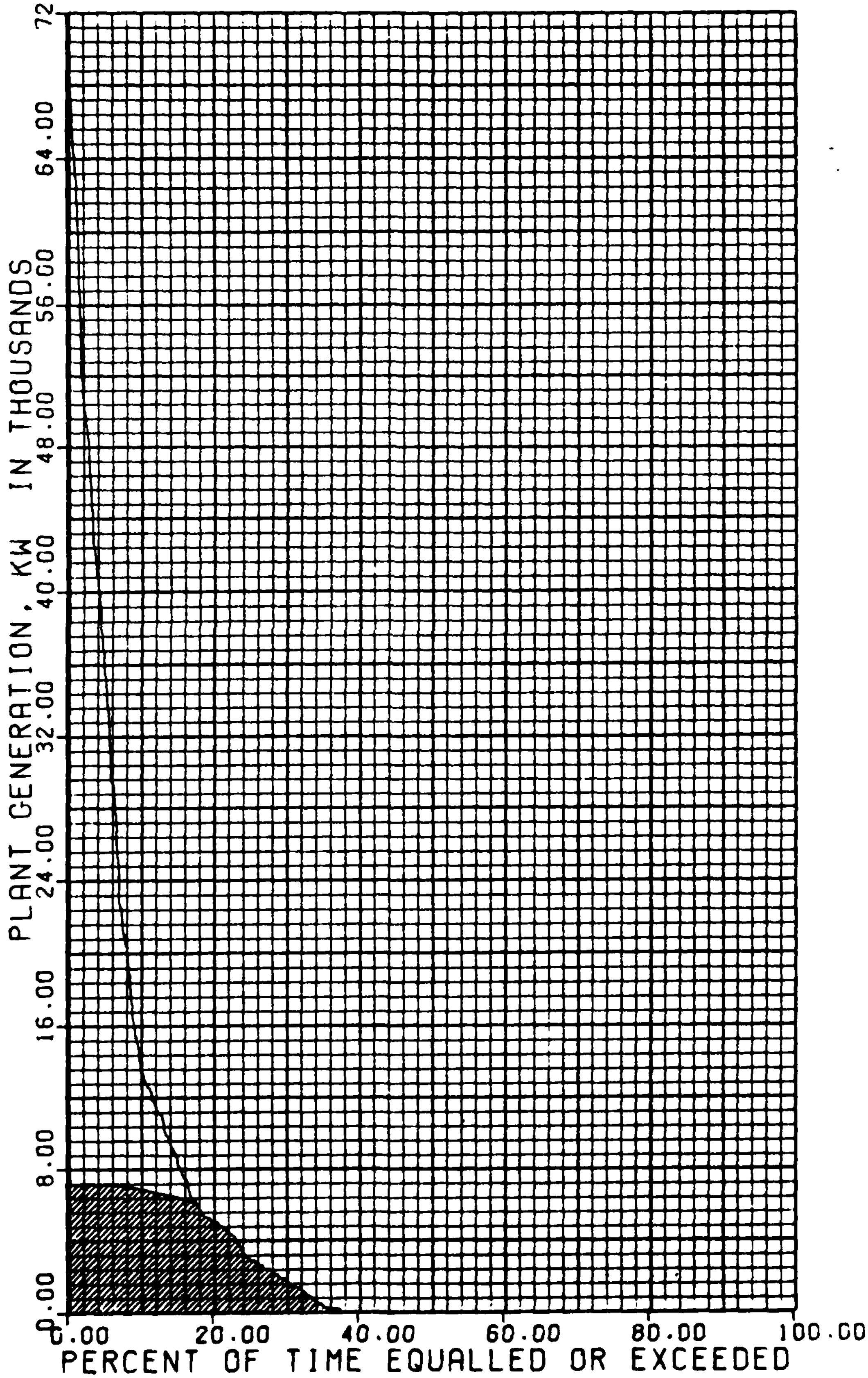
LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR JAN
USING DAILY DATA

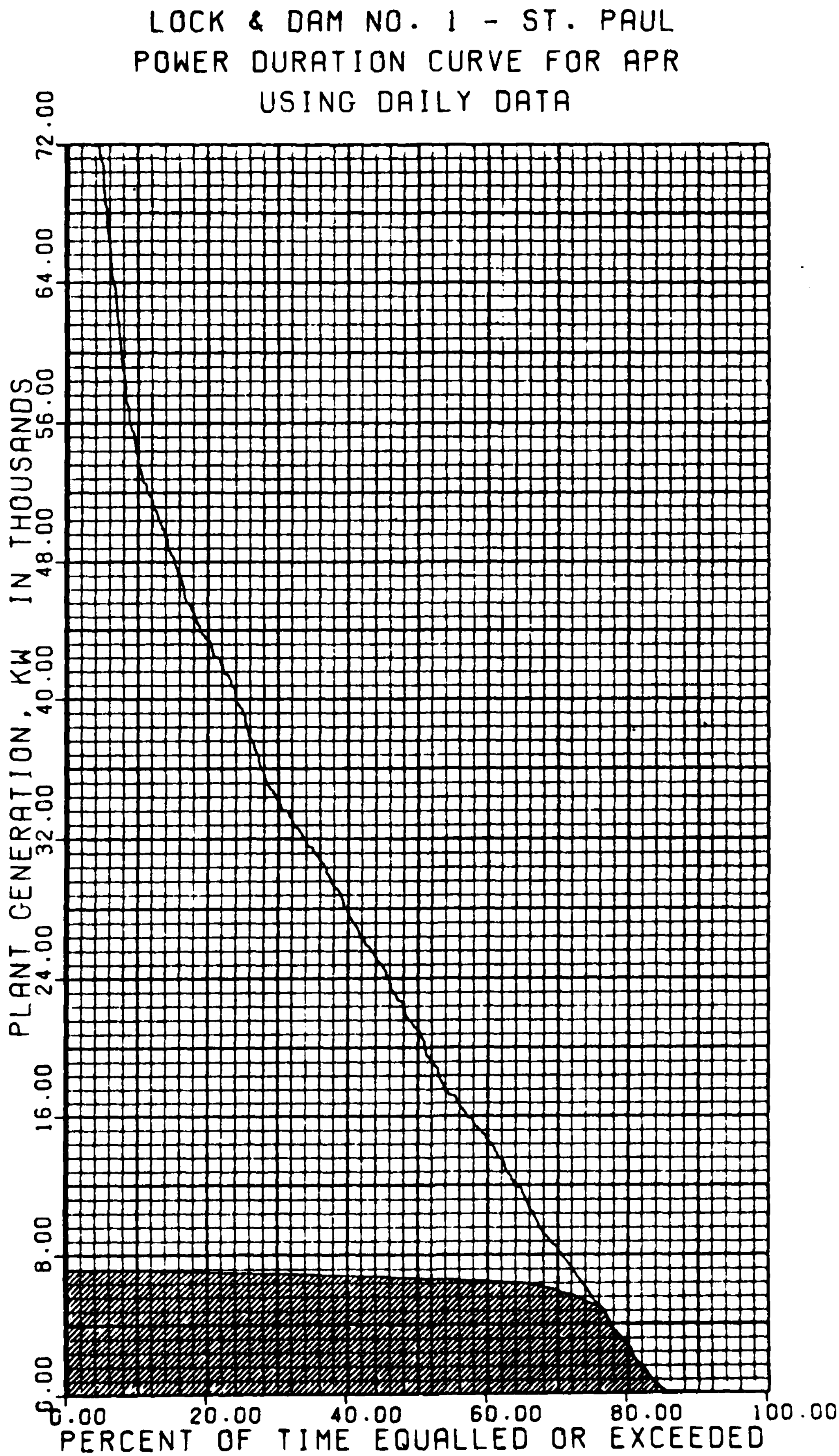


LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR FEB
USING DAILY DATA

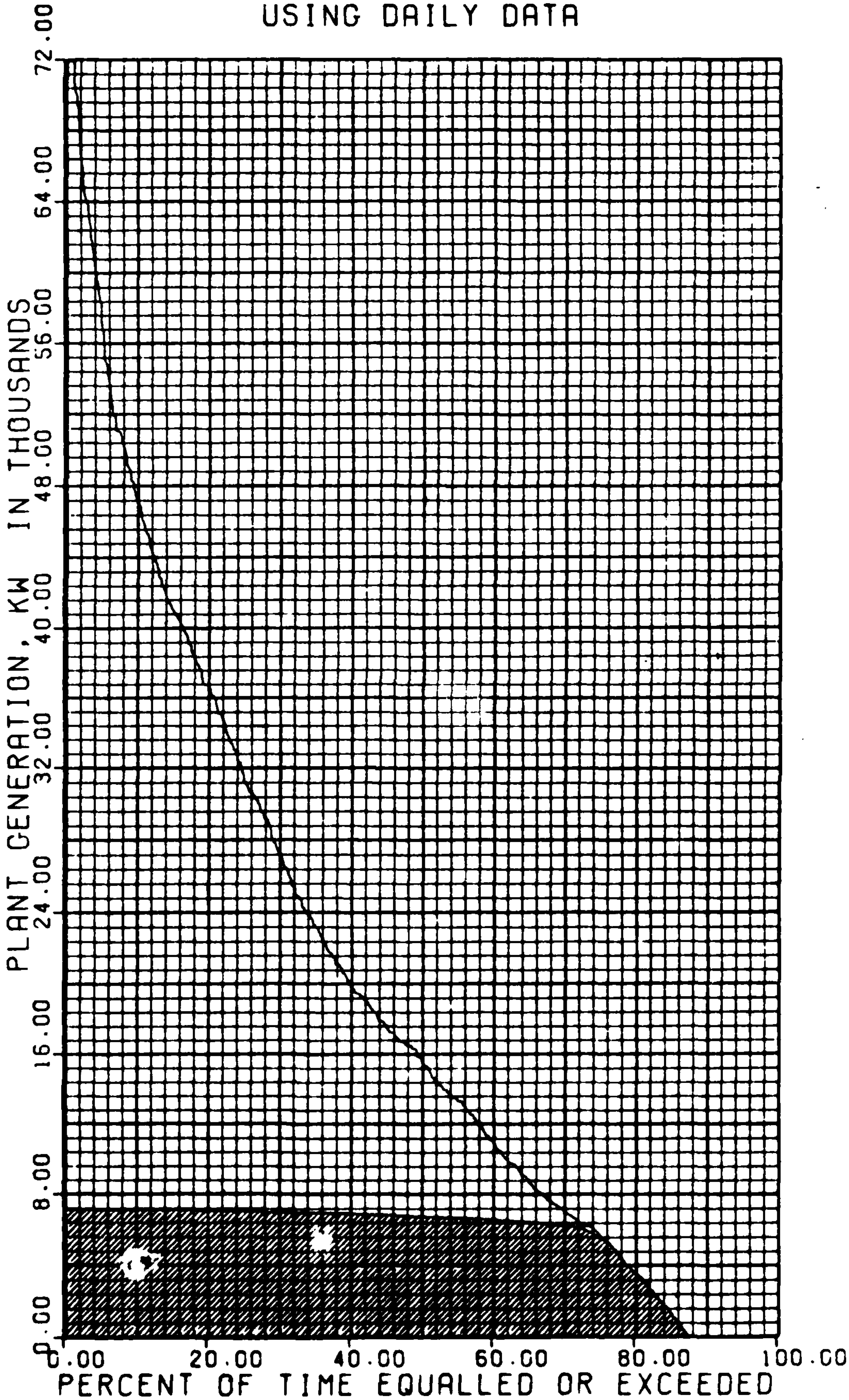


LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR MAR
USING DAILY DATA

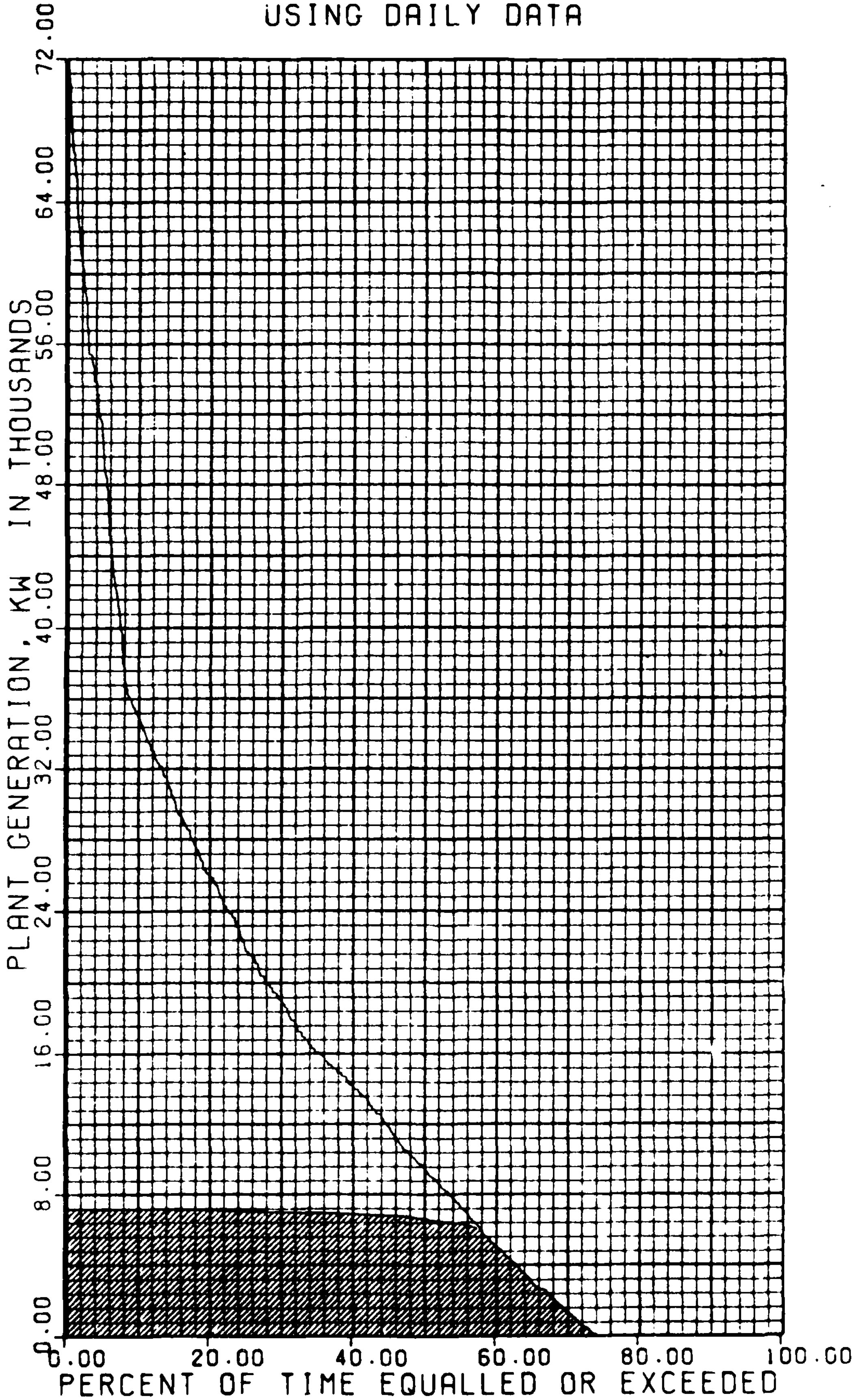


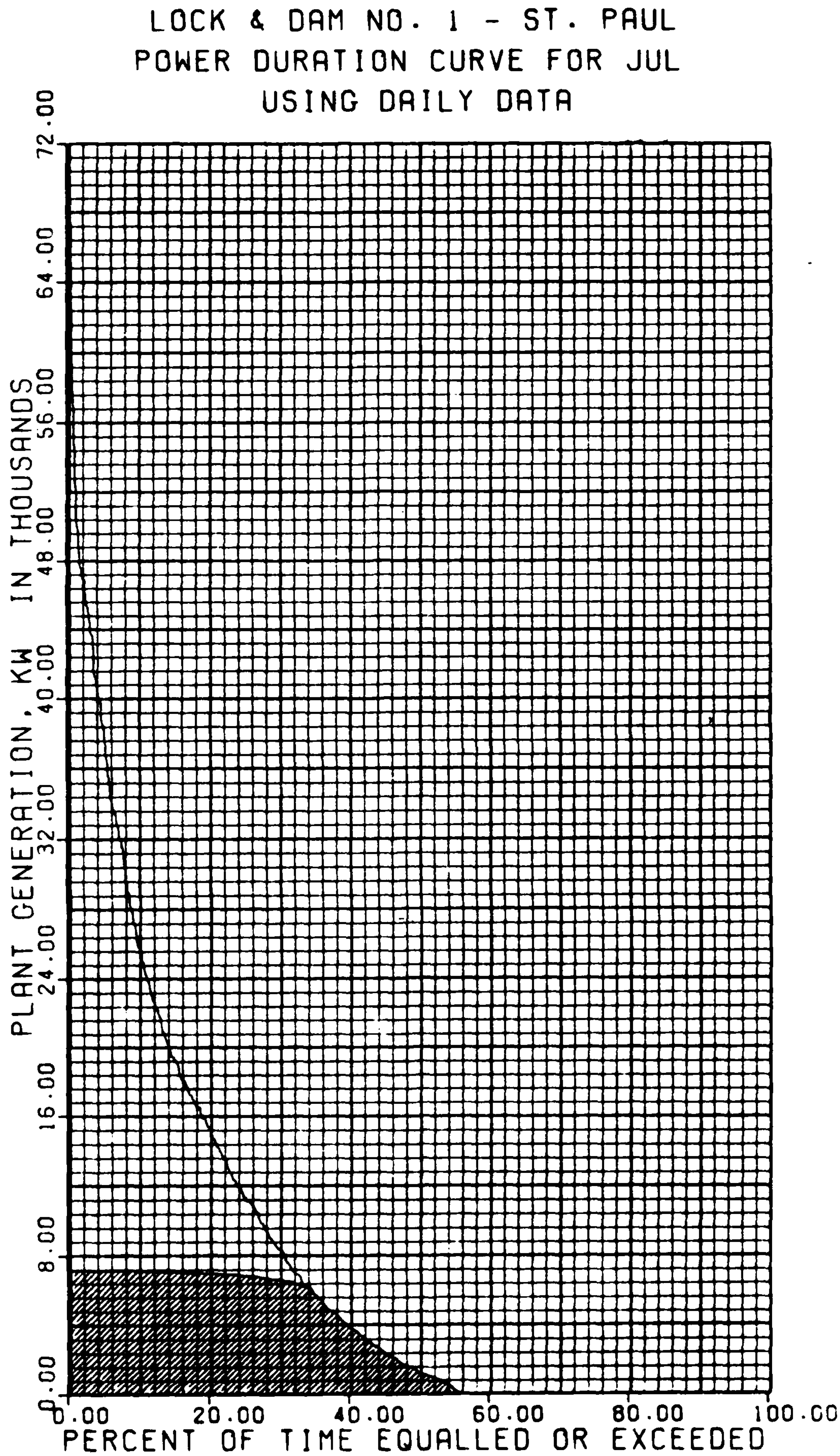

LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR APR
USING DAILY DATA
PLANT GENERATION, KW IN THOUSANDS
0.00
8.00
16.00
24.00
32.00
40.00
48.00
56.00
64.00
72.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED

LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR MAY
USING DAILY DATA

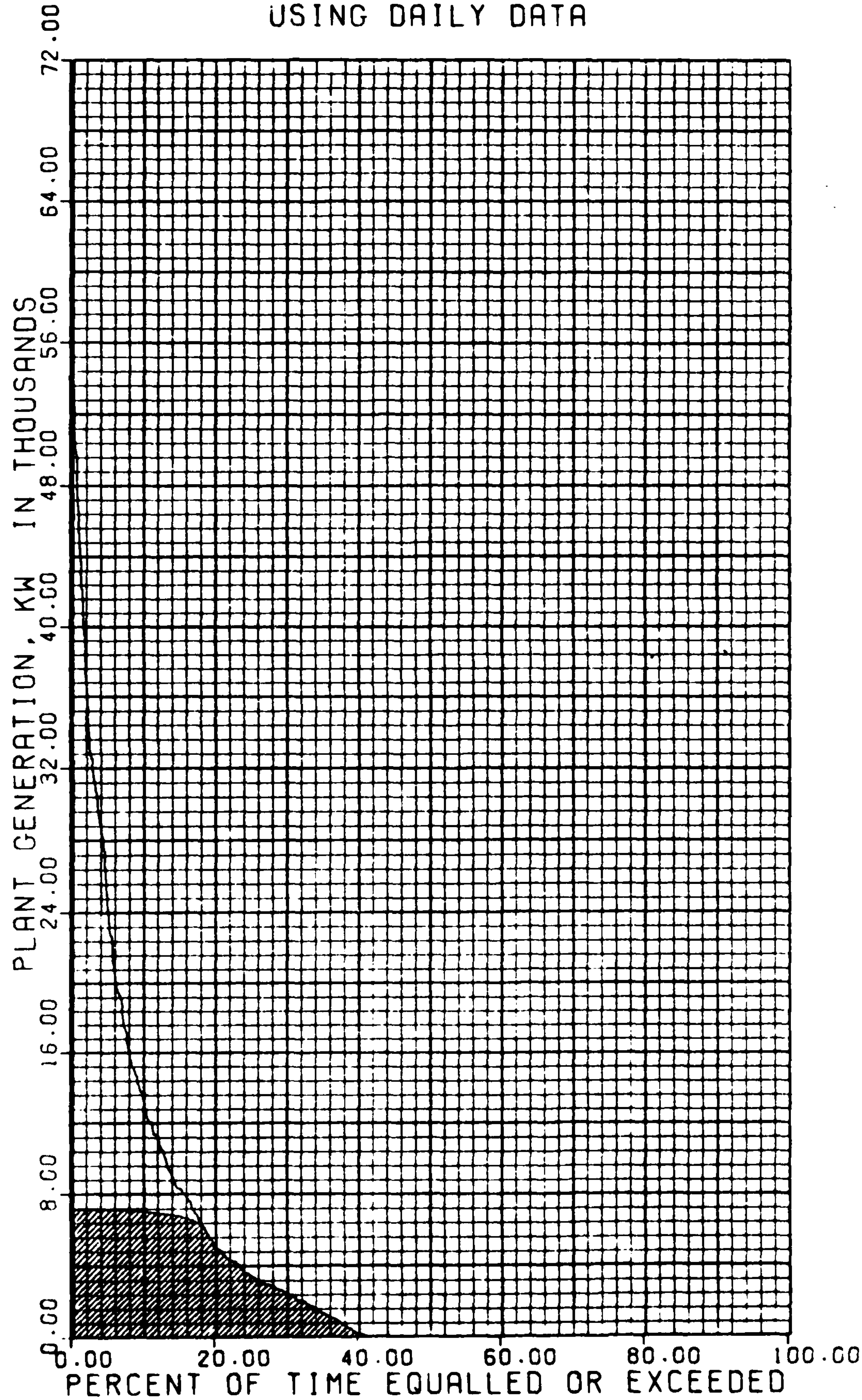


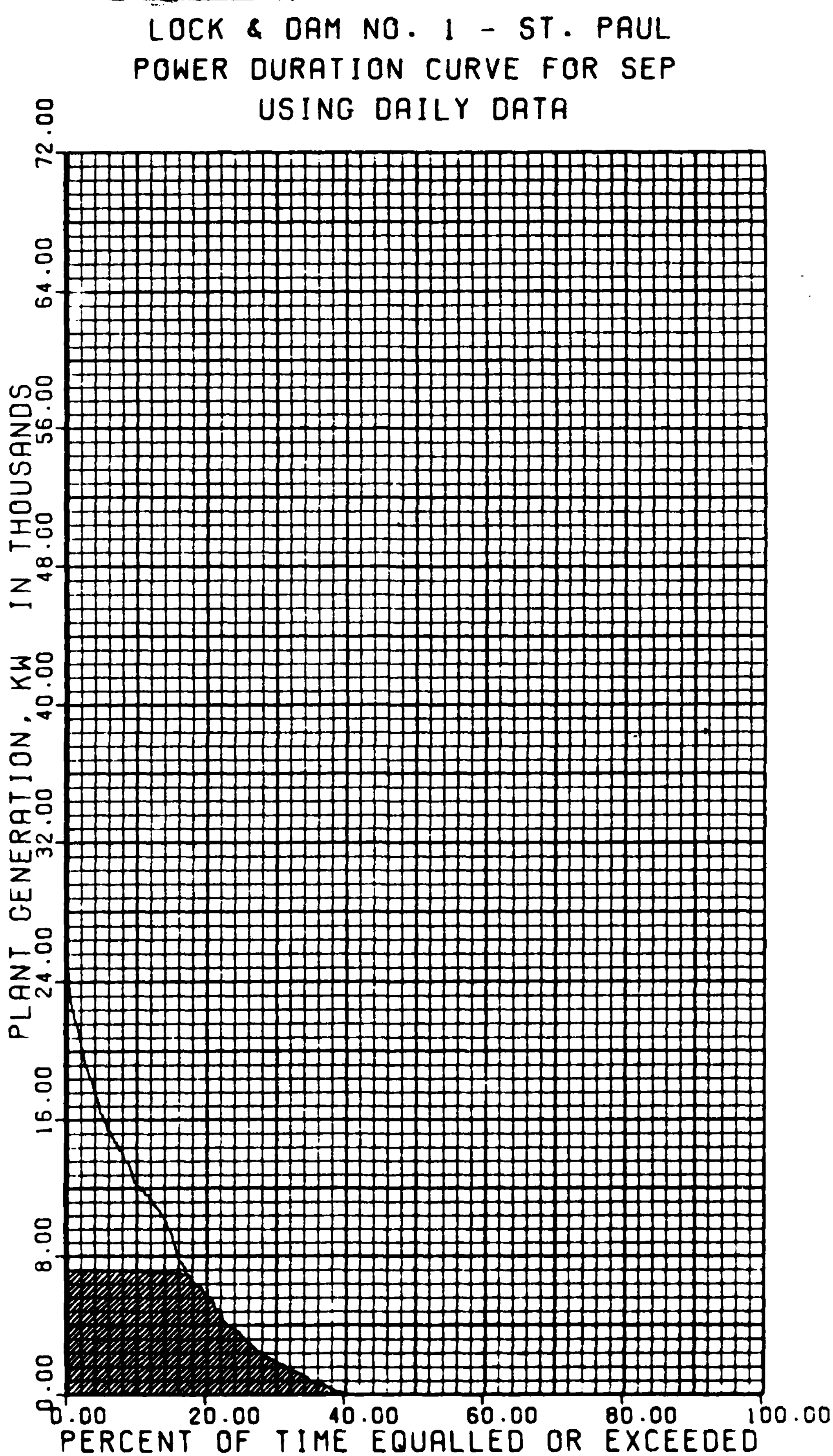
LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR JUN
USING DAILY DATA

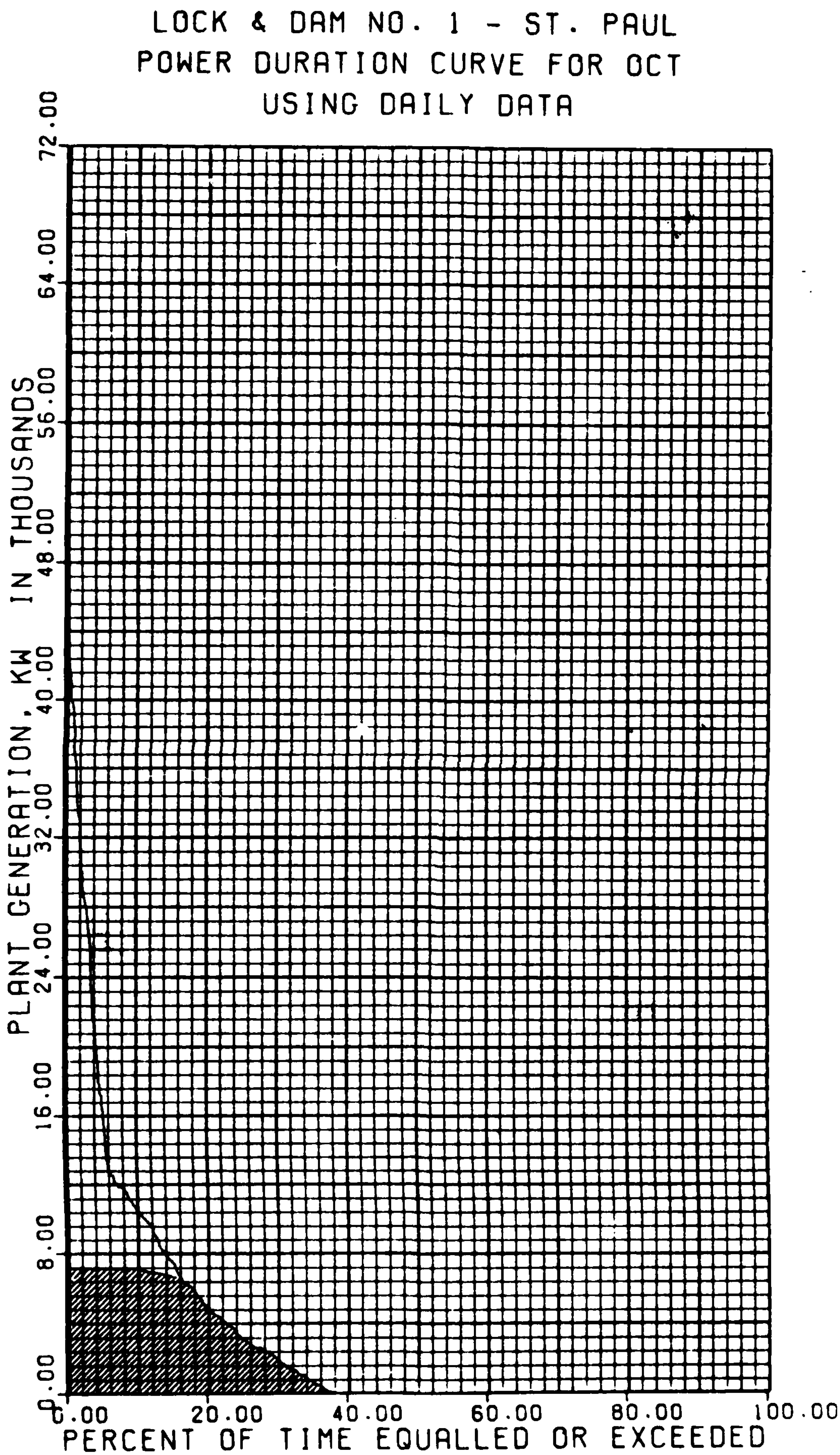



LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR JUL
USING DAILY DATA
PLANT GENERATION, KW IN THOUSANDS
0.00
8.00
16.00
24.00
32.00
40.00
48.00
56.00
64.00
72.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED

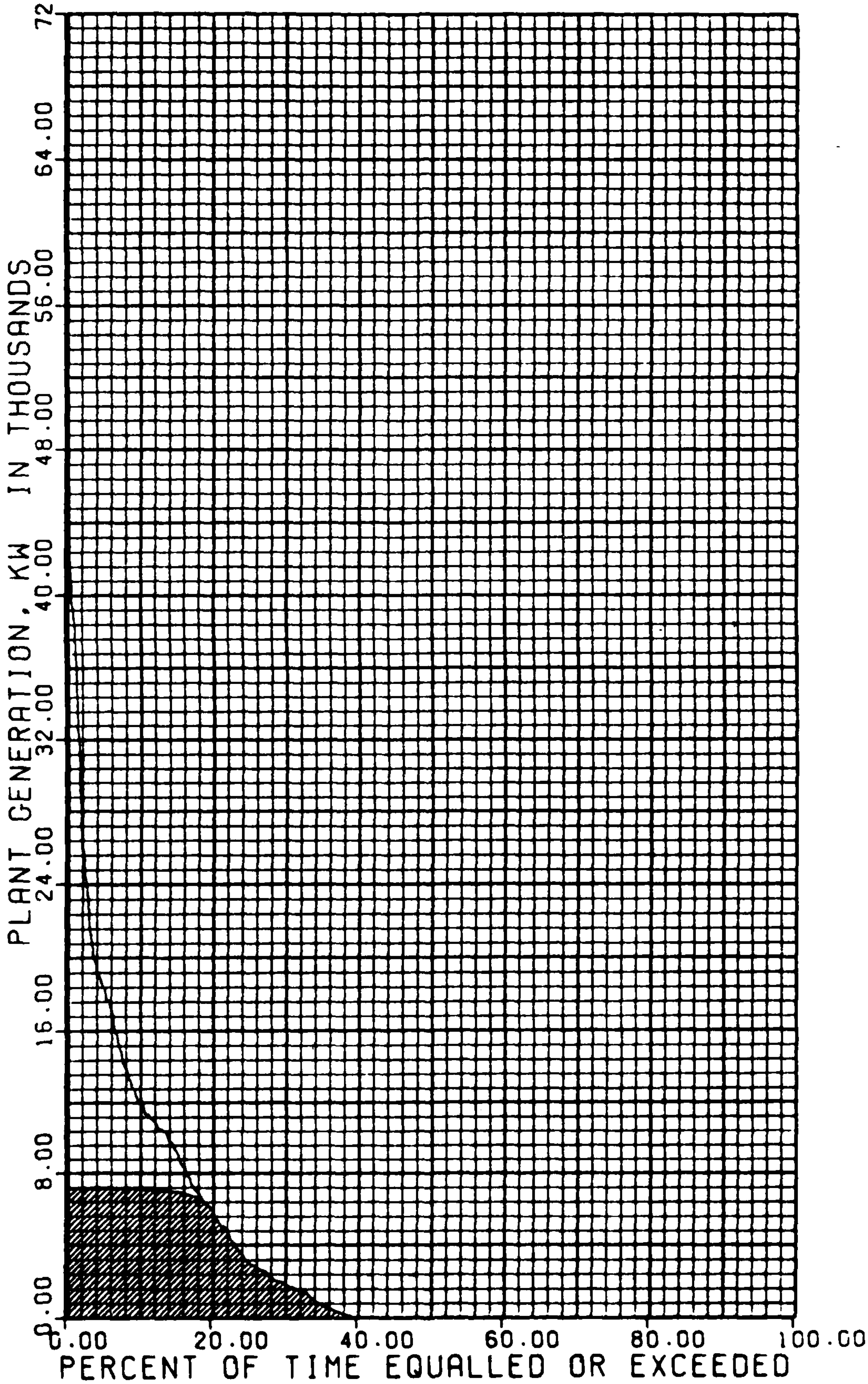
LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR AUG
USING DAILY DATA



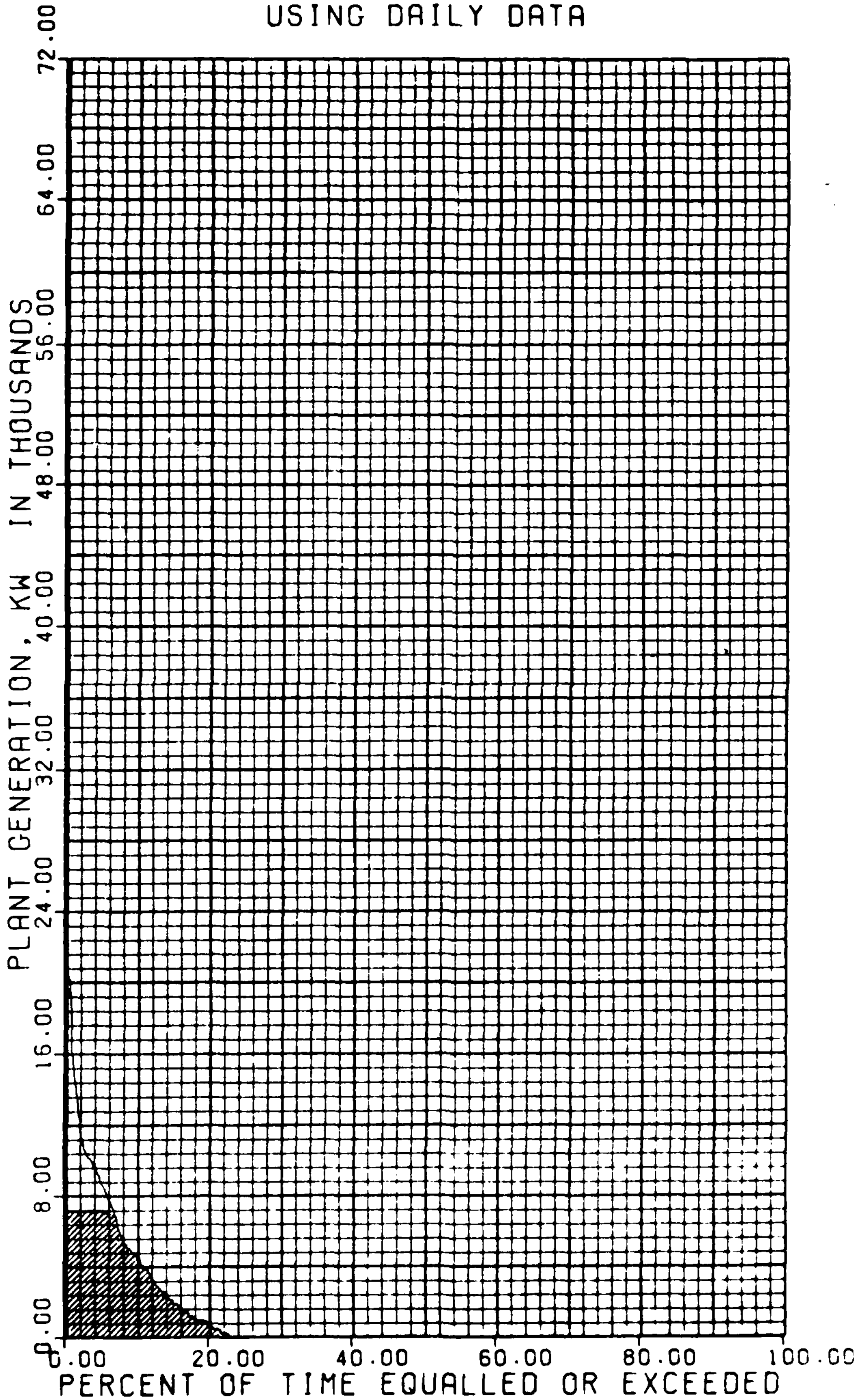

LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR SEP
USING DAILY DATA
PLANT GENERATION, KW IN THOUSANDS
0.00
8.00
16.00
24.00
32.00
40.00
48.00
56.00
64.00
72.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED

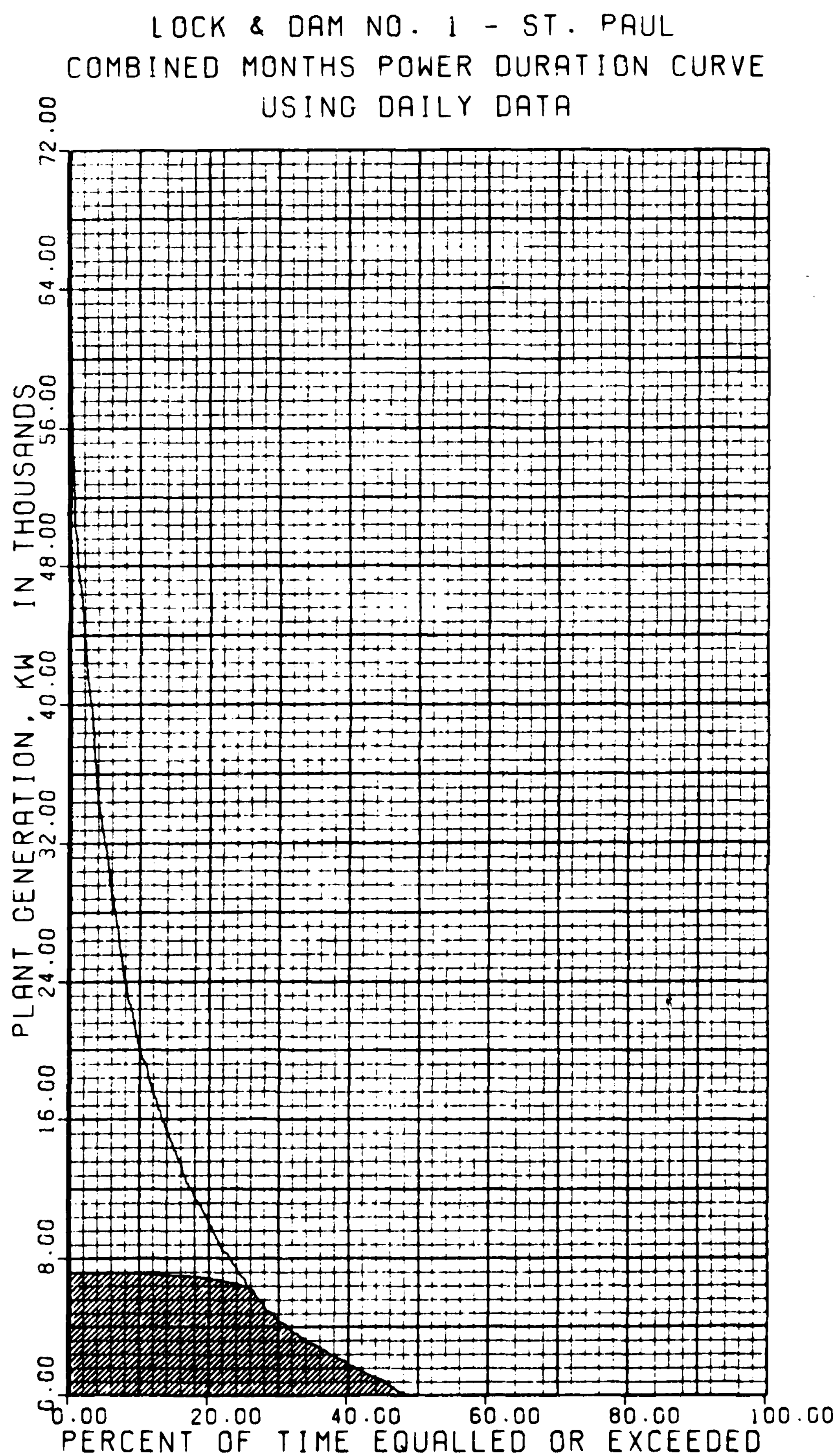

LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR OCT
USING DAILY DATA
PLANT GENERATION, KW IN THOUSANDS
0.00
8.00
16.00
24.00
32.00
40.00
48.00
56.00
64.00
72.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED

LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR NOV
USING DAILY DATA



LOCK & DAM NO. 1 - ST. PAUL
POWER DURATION CURVE FOR DEC
USING DAILY DATA




LOCK & DAM NO. 1 - ST. PAUL
COMBINED MONTHS POWER DURATION CURVE
USING DAILY DATA
PLANT GENERATION, KW IN THOUSANDS
72.00
64.00
56.00
48.00
40.00
32.00
24.00
16.00
8.00
0.00
20.00
40.00
60.00
80.00
100.00
PERCENT OF TIME EQUALLED OR EXCEEDED

APPENDIX D

Pertinent Correspondence

PRECEDING PAGE BLANK-NOT FILMED

FEDERAL ENERGY REGULATORY COMMISSION
CHICAGO REGIONAL OFFICE
230 SOUTH DEARBORN STREET, ROOM 3130
CHICAGO, ILLINOIS 60604

October 11, 1983

Mr. Louis Kowalski
Chief, Planning Division
St. Paul District, Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Mr. Kowalski:

Your August 26, 1983 letter requests power values, developed at discount rates of 8.125 and 14.0 percent and based on October 1983 price levels, for Upper St. Anthony Falls, Lower St. Anthony Falls, and Lock and Dam No. 1.

Power values, based on a coal-fueled steam-electric plant as the most likely alternative to each of the above-proposed hydroelectric developments, are summarized on the attached table. These are "at market" values; no transmission line costs for the hydroelectric development have been included.

The energy values for the hydroelectric developments were determined by the difference in total system operating cost between a system utilizing the proposed hydro installation and one using an alternative steam-electric generating plant. System operating costs were simulated using the POWRSYM Version 48 production costing model.

Northern States Power Company was used as a "typical" system to measure the annual production cost differences between future operation with the added hydro capacity and its alternative. Operation of the system was simulated over a 30-year period based on load and energy requirements for the Northern States Power Company system.

If you have any questions regarding these power values, please contact Mr. David Simon of my staff at (FTS) 353-6701, and he will assist you.

Sincerely,

Lawrence F. Coffill

Lawrence F. Coffill, P.E.
Regional Engineer

Enclosure:
as stated

DOE/FERC/CRO
October 1093

Power Values at October 1983 Cost Levels

	Capacity Value 1/ ($/kW-yr)		Energy Value ($/mwh) Current	Escalated	
	@8.125%	@14.0%	-	@8.125%	@14.0%
St. Anthony Falls Upper Dam	201.10	348.80	24.5	31.4	31.2
Lower Dam	201.10	348.80	21.6	27.7	27.5
Lock and Dam 1	201.10	348.80	24.1	30.9	30.7

1/ These data do not include hydrologic availability.

Summary of input data:

Coal plant investment cost
@ 8.125% $1,370/kW
@ 14% $1,598/kW

Coal plant fuel cost - $1.74 per million Btu

Unadjusted Capacity Value
@ 8.125% $149.40 kW-yr
@ 14% $259.20 kW-yr.

Unadjusted Energy Value - $18.9/Mwh

Operating flexibility credit included in capacity values - 5 percent

Mechanical availability adjustment included in capacity values = $\frac{\text{Hydro Avail}}{\text{Coal Avail}} = \frac{0.985}{.76} = \underline{1.296}$

Plant on-line date 1990

Fuel escalation based on November 11, 1981 DOE projections

1980-1985	13.80%
1985-1990	2.00%
1990-2010	0.18%

TELEPHONE OR VERBAL CONVERSATION RECORD

For use of this form, see AR 340-15, the proponent agency is The Adjutant General's Office

DATE: 9 May 1983

SUBJECT OF CONVERSATION

St. Anthony Falls Hydropower -- Marketability

INCOMING CALL

PERSON CALLING	ADDRESS	PHONE NUMBER AND EXTENSION
PERSON CALLED	**OFFICE**	**PHONE NUMBER AND EXTENSION**

OUTGOING CALL

PERSON CALLING	OFFICE	PHONE NUMBER AND EXTENSION
Orval W. Bruton	NPDEN-WM-Power Section	FTS 423-3752
PERSON CALLED	**ADDRESS**	**PHONE NUMBER AND EXTENSION**
Truman Price	Director Division of Water and Power Resources, DOE	FTS 633-8336

SUMMARY OF CONVERSATION:

1. A call was placed to Mr. Price to discuss marketing of the new generation at the St. Anthony Falls project.

2. Mr. Price said that the Corps' generated power could be marketed to any of the 800 public entities in the region. There is an apparent need for this type of relatively low cost generation in the region. Informally, he gave assurance that the power can be marketed through the Department of Energy. Appropriately, a formal request for a marketability statement will be made by St. Paul District, Corps of Engineers.

Orval W. Bruton

ORVAL W. BRUTON, P.E.
Power Section NPD

DA FORM 1 APR 66 751 REPLACES EDITION OF 1 FEB 58 WHICH WILL BE USED. ☆U S GPO 1981-0-785-042/1038

TELEPHONE OR VERBAL CONVERSATION RECORD

For use of this form, see AR 340-15, the proponent agency is The Adjutant General's Office

DATE: 21 December 1982

SUBJECT OF CONVERSATION: Lock & Dam No. 1 Tailwater Elevation Data

INCOMING CALL

PERSON CALLING	ADDRESS	PHONE NUMBER AND EXTENSION
PERSON CALLED	**OFFICE**	**PHONE NUMBER AND EXTENSION**

OUTGOING CALL

PERSON CALLING	OFFICE	PHONE NUMBER AND EXTENSION
Orv Bruton	NPDEN-WM-Power Section	FTS 423-3752
PERSON CALLED	**ADDRESS**	**PHONE NUMBER AND EXTENSION**
Gordon Heizman	St. Paul District	

SUMMARY OF CONVERSATION:

1. A call was placed to St. Paul District, Hydraulics Section so that corrections could be made to the existing tailwater-elevation curve shown in the Reservoir Regulation Manual, dated November 1979, Plate 6. Mr. Heizman said the tailwater curve published in the manual is in error and corrections should be made.

2. The tailwater elevation at Lock & Dam No. 1 is affected by the natural flow at the project <u>and</u> by some unrelated physical features downstream. The Minnesota River has its confluence with the Mississippi River about 5 miles below the dam and its backwater effects can influence Lock & Dam 1 tailwater. Also the general configuration of the Mississippi River and the pool conditions of Lock and Dam No. 2 can affect the tailwater of Lock and Dam No. 1.

3. There is no exact flow - tailwater relationship at the dam, but the Minnesota River confluence does have significant effect, it was, therefore, decided to compare different flows of the Mississippi and Minnesota Rivers with actual recorded tailwater elevations at Lock and Dam No. 1. The following is a sampling of data taken from river gages and recorded tailwater elevations.

RECORDED FLOW & TAILWATER DATA

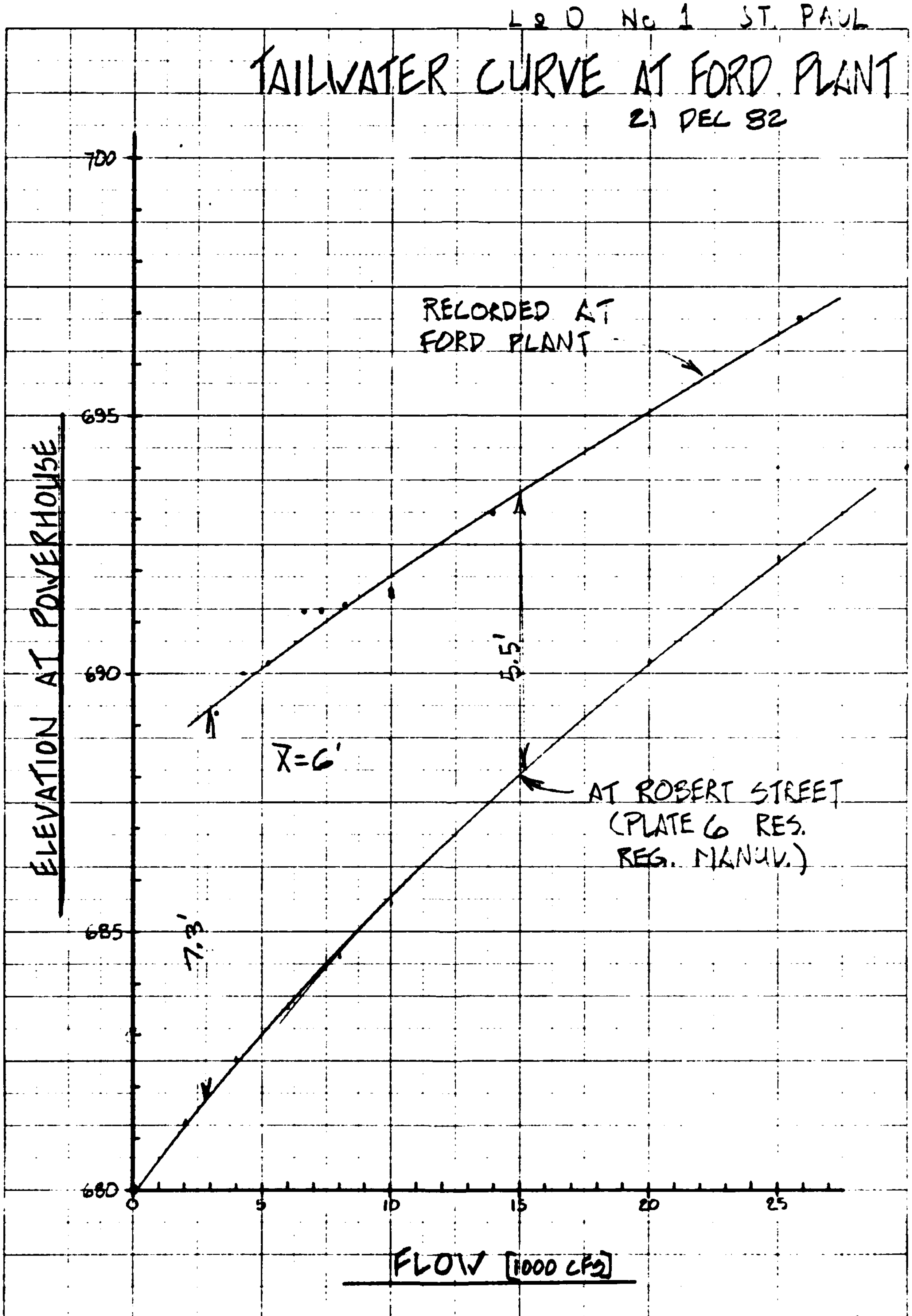
(1) Flow, cfs Miss R.	(2) Flow, cfs Minn. R.	(3) T.W. Elev Lockside	(4) T.W. Elev Ford Plant	Diff. Col. 3&4
3,200	1,100	687.4	689.1	1.7
4,300	1,500	687.9	690.0	2.1
5,200	1,500	688.3	691.1	2.8
6,600	2,300	689.0	691.1	2.1
7,300	4,400	689.0	691.1	2.1
8,206	5,700	689.3	691.3	2.0
10,000	2,000	689.5	691.6	2.1
10,000	4,000	689.4	691.5	2.1
[illegible]	5,000	691.7	693.1	1.4
25,800	[illegible]	696.1	696.9	0.8
45,500	14,000	701.6	702.2	0.6

4. The flows of the Mississippi River (Col. 1) were plotted against the T.W. Elevation at the Ford Plant (Col. 4). This curve was then compared with the tailwater curve published in the Reservoir Regulation Manual, Plate 6, (attachment 1). From the data shown on the curves, it was decided to use a 6.0 foot constant correction to the tailwater curve data in the Reservoir Regulation Manual. This corrected data will be used to prepare a new tailwater rating curve for use in the Lock and Dam No. 1 hydropower studies.

Orv Bruton

Attachment
as

ORV BRUTON, P.E.
Hydropower Coordinator
North Pacific Division



Attachment 1

TELEPHONE OR VERBAL CONVERSATION RECORD For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office		DATE 14 December 1982
SUBJECT OF CONVERSATION: Upper Mississippi Critical Load Months -- St. Anthony Falls and L & D No. #1 Projects		
INCOMING CALL		
PERSON CALLING	ADDRESS	PHONE NUMBER AND EXTENSION
PERSON CALLED	OFFICE	PHONE NUMBER AND EXTENSION
OUTGOING CALL		
PERSON CALLING Orv Bruton	OFFICE NPDEN-WM-PWR	PHONE NUMBER AND EXTENSION FTS 423-3752
PERSON CALLED Jim Kolak	ADDRESS FERC - Chicago Office	PHONE NUMBER AND EXTENSION FTS 353-6701

SUMMARY OF CONVERSATION:

1. A call was placed to the Chicago Federal Energy Regulatory Commission Office to discuss the critical load months for the subject projects.

2. The area power load, currently served chiefly by Northern States Power, has two periods of critical demand:

a) Summer months July - August
b) Winter months December - January

3. Mr. Kolak said that his office uses only the two summer months (July-August) for their critical peak load determination. While the winter months also represent high demand months, they are not as critical as the summer months.

4. For St. Anthony Falls and Lock & Dam No. #1 studies, the two summer months will be used to determine dependable capacity.

Orv Bruton

Orv Bruton, P.E.
Study Coordinator

DA FORM 1 APR 66 751 REPLACES EDITION OF 1 FEB 58 WHICH WILL BE USED

U.S. GPO 1981-0-785-042/1036

(

TELEPHONE OR VERBAL CONVERSATION RECORD

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office

DATE: 24 November 1982

SUBJECT OF CONVERSATION: St. Anthony Falls Project and Lock & Dam No. #1 Project

INCOMING CALL

PERSON CALLING	ADDRESS	PHONE NUMBER AND EXTENSION
PERSON CALLED	**OFFICE**	**PHONE NUMBER AND EXTENSION**

OUTGOING CALL

PERSON CALLING	OFFICE	PHONE NUMBER AND EXTENSION
Orv Bruton	NPDEN-WM-PWR	FTS 423-3752
PERSON CALLED	**ADDRESS**	**PHONE NUMBER AND EXTENSION**
Carl Stephen	St. Paul District	FTS 725-7472

SUMMARY OF CONVERSATION:

1. A call was placed to verify the use of the flashboards on the subject projects. Flashboards, two-feet high are used on the Upper Falls of St. Anthony project and on Lock and Dam 1 project. These flashboards are manually raised every year after the spring runoff and the flashboards go down as the river flow and ice flows increase in early spring. The flashboards automatically drop by shear-pin failure when the flow reaches a certain point (see regulation manual). In certain low flow years the flashboards do not go down at all -- while in other years (such as 1982) they go down as early as October.

2. For the hydropower studies at both projects assume the following:

Flashboards Up	1 July - 28 February
Flashboards Down	1 March - 30 June

3. Power Section will modify the Duraplot program to reflect the 2-foot increase in generating head for the months shown above.

Orv Burton

ORV BURTON, P.E.
Study Coordinator

DA FORM 1 APR 66 751 REPLACES EDITION OF 1 FEB 58 WHICH WILL BE USED. ☆U.S.GPO 1981-0-765-042/1038

AGENDA

MEETING WITH NPD ON HYDROPOWER
LOCK AND DAM 1

Wednesday, 3 November 1982

Arrive MSP airport - RON

Thursday, 4 November 1982

8:30 a.m.	Meet with study manager at St. Paul District office - Room 1228
9:00 a.m.	Leave for L/D 1 via gov't. van
9:30-10:30 a.m.	Inspect L/D 1
10:30-11:30 a.m.	Inspect Ford Motor Company's hydroelectric plant at L/D 1
11:30-1:00	Lunch and return to District office
1:00-2:00 p.m.	Informal meeting with NCS hydro study managers
2:00-4:00 p.m.	Meet with District study team members (Room ~~633)~~ 729

Friday, 5 November 1982

NPD return to Portland, OR

FORD MOTOR COMPANY

TWIN CITIES HYDRO ELECTRIC POWER PLANT

The plant was constructed in 1924 by the Ford Motor Company at a cost of $1.5 million.

The building ia 160' long x 74' wide and is 51' high. The four Westinghouse generators installed in 1924 are still operational today. Each unit is a 72 pole, 4500 KVA generator that runs at 100 RPM and provides an equivalent 18,000 H.P. Each rotor ia aupported by a 32 inch Kingsbury bearing located under the exciter, totally emerged in a bath of turbine oil. The diameter of the generator shaft measures 16 inches. The rotor and auxiliaries weigh 58 tons.

The turbines are Willman-Seaver Morgan Francis reaction type units, set in a 10 foot 9 inch circle of wicker gates, Each turbine is rated for 4500 h.p. when the head water is 34 feet. Each turbine has a water rate of 1500 cubic feet per second at full load. The river flow varies from 4,000 to 25,000 cubic feet per second seasonally. During the winter season, when ice forms on the river, the water flow decreases to an average of 5,000 cubic feet per second.

Woodward governors control the mechanism, activated by 125 pounds of hydraulic oil pressure supplied by two motor driven oil pumps located in the basement adjacent to the oil resevoirs.

The generators produce 13,800 volts of current, which is transmitted by underground cable and transformed to 440-220 and 110 volt current for distribution. The total daily power output averages close to 250,000 KWH.

The Federal license under which Ford operates the Hydro facility requires that the generators run at full capacity as determined by the river flow. Ford furnishes the U.S.Government with all the electrical power required to heat, light and operate the Locks across the river free of charge. With the new facilities installed in the 1981-82 Lock rehabilitation project, power used by the government exceeds 500,000 KWH annually.

Approximately 50% of the power generated is consummed by the Ford Assembly Plant, which normally operates on a five day,sixteen hour per day production schedule. Any surplus power beyond that used by the government locks, the assembvly plant and the hydro plant itself, is transmitted to Northern States Power Company in St. Paul for re-distribution to general consumers in the area.

Ford is proud to be the largest non-utility producer of alternate energy in the state of Minnesota, and intends to continue its hydro operation as long as taxes and regulatory statutes are not excessively prohibitive to an economically sound operation.

DAM and LOCK #1

The locks and dam were constructed in 1912 by the Corp of Engineers at a cost of $3.9 million. The dam is 574 feet long with a fixed overflow spillway. There are 36 hinged flashboards attached to the top of the dam to increase the water head to 34 feet and to provide a 9 foot channel for river navigation. The flashboards are designed to tip and release water when the pressure becomes too heavy.

The pool created by the dam extends to the Northern Pacific Railway bridge located 5.4 miles up river.

The U.S. government spent $45 million during 1981-82 to refurbish the locks to ensure continued and more efficient navigational capabilities with improved water saftey equipment.

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
1135 U. S. POST OFFICE & CUSTOM HOUSE
ST. PAUL, MINNESOTA 55101

REPLY TO
ATTENTION OF:

NCSPD-PF

15 OCT 1982

SUBJECT: Use of Hydroelectric Design Center - Lock and Dam 1

Commander
U.S. Army Engineer Division, North Pacific
P.O. Box 2870
Portland, Oregon 97208

1. Reference: Telephone conversation between Mr. Orval Bruton, Chief, NPD Power Section, and Mr. Herb Nelson, NCS, study manager.

2. The St. Paul District is starting a hydroelectric feasibility study in fiscal year 1983 for lock and dam 1 on the Mississippi River between Minneapolis and St. Paul, Minnesota. We completed a reconnaissance study in September 1981 (copy inclosed) using standardized units. The reconnaissance study indicates economic feasibility for added development at the site, which already has generating capacity.

3. Lock and dam 1 is operated for both hydropower and navigation. The St. Paul District controls and operates the navigation locks on the right bank of the river, and the Ford Motor Company operates the existing power facilities on the left bank. The installed capacity is 14.4 megawatts. The present licensee (Ford) is not interested in further development of the site at this time. The existing powerplant is operated to be compatible with water surface elevations required for navigation. Any new development would also be subject to the same constraint. Inclosed are copies of the reservoir regulation manual and the annual flow-duration and head-flow curves.

4. During the reconnaissance study, two potential powerhouse sites were identified. We will analyze the potential for additional alternative sites when we receive study funding. However, it now appears that no significantly different locations are available at lock and dam 1. A preliminary review of ponding operation at St. Anthony Falls indicates that this type of operation would not be appropriate at lock and dam 1 and would be inconsistent with the navigation purpose of this project.

5. We are interested in using the services of the Hydroelectric Design Center in our feasibility studies for this site. We expect the Design Center could initially develop a technical report similar to the one being produced for St. Anthony Falls.

NCSPD-PF
SUBJECT: Use of Hydroelectric Design Center - Lock and Dam 1

6. When we receive study funding, we will transfer funds for further coordination and a possible trip to the site. The tentative schedule is as follows:

November 1982	Field trip to lock and dam 1
December 1982	Scope of work approved
1 March 1983	Technical report completed

7. If you have any comments or questions, please contact us.

3 Incl
as

EDWARD G. RAPP
Colonel, Corps of Engineers
Commanding